Individual and Group Characteristics and their Economic Implications

by

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Thesis

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I will always be thankful for the sometimes strange but often helpful discussions with all my friends and classmates during my PhD.

I especially want to thank my father for his persistence to push me to my limits throughout my education and life. He is the reason I am able to accomplish this. His perseverance in life has been my inspiration to never stop.

I dedicate this work to my mother. Despite her absence, I have always felt her influence.

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Declarations

This work has not been submitted for a degree at another university.

The first chapter is my own work.

The second chapter is collaborative work with Gordon Brown. The basic idea was developed through joint discussions, while the implementation and write-up was done by myself.

The third chapter is collaborative work with Eugenio Proto and Aldo Rustichini. The design and basic idea resulted through joint discussions. The implementation of the experimental sessions as well as the programming for experimental software was done by myself. The analysis was performed through joint discussions, while the write-up and final editing was shared equally.

Abstract

This thesis is a collection of studies about the link between individual and group characteristics and economic outcomes.

The first chapter investigates the link between declared trusting attitudes and trust choices in an infinitely repeated trust game after controlling for subjective beliefs. It is found that intrinsic trust influences the probability of trusting in a trust game. Moreover, intrinsic trust seems to operate through the fact that more trusting individuals are more likely to forgive or offer the benefit of doubt to others and show trust even after a disappointing outcome. The effect of intrinsic trust appears to be independent of the formation of beliefs.

The second chapter studies personality trait variation and its implications on society's welfare. Personality is taken to be a type of skill that can be better understood if considered as a distribution rather than a single point. The ABM simulation results reported show that population personality compositions are adaptive on the task (job) distribution. Further simulation results depict the importance for appropriate education to cater for the jobs in the economy. Finally, simulations indicate that precise job match screening is beneficial not only for society's welfare but also for subjective well-being.

The third chapter is concerned with how intelligence affects the social outcomes of groups. A systematic study of the link is provided in an experiment where two groups of subjects with different levels of intelligence, but otherwise similar, play a repeated prisoner's dilemma. Initial cooperation rates are similar, but increase in the groups with higher intelligence to reach almost full cooperation, while they decline in the groups with lower intelligence. Cooperation of higher intelligence subjects is payoff sensitive and not automatic: in a treatment with lower continuation probability there is no difference between different intelligence groups.

Abbreviations

ABM	Agent Based Modelling
APM	Advanced Progressive Matrices
DBF	Dal Bò and Fréchette (2011)
DRAW	Decision Research at Warwick
GDP	Gross Domestic Product
IPIP	International Personality Item Pool
NEO	Neuroticism-Extraversion-Openness
PI-R	Personality Inventory - Revised
SWB	Subjective well-being
Z-Tree	Zurich Toolbox for Ready-made Economic Experiments

Chapter 1

Personality and Trust in an Infinitely Repeated Trust Game

1.1 Introduction

> "You must trust and believe in people or life becomes impossible." Anton Chekhov

> "Virtually every commercial transaction has within itself an element of trust, certainly any transaction conducted over a period of time." (Arrow, 1972, p.357)

Extending trust towards others is necessary if society is to flourish. Trust is an important element of many social and economic transactions. For example, an employer assigns responsibilities to an employee based on trust, spouses trust each other to be faithful, and citizens trust elected officials to champion their interests. The problem is that there is not always perfect information on the reciprocity or exploitation of trust.

The importance of trust for growth (Algan and Cahuc, 2010), well-being (Algan and Cahuc, 2013) and democracy (Putnam et al., 1993) has been documented.

Butler et al. (in press) investigate the relation between individual trust and individual economic performance. They found that higher levels of trust were associated with lower incomes.

Given the importance of trust, a key question that arises is what (if any) individual characteristics can help sustain trust? In this paper we examine whether personality traits can explain the choices of individuals to trust or not. Specifically, we examine whether the Agreeableness factor of the 'Big Five' is the motivator for more trust, or whether the specific trust facet of Agreeableness is the key relevant characteristic. When discussing advantages and disadvantages of the different Big Five factors, Nettle (2006) notes that Agreeableness is generally found to correlate with more pro-social attitudes. As he also notes, however, Agreeableness could also be detrimental given the possibility of exploitation; the present paper is motivated partly by this suggestion. We aim to establish whether there exists a link between Agreeableness and trusting behaviour.

The experiment we present in this paper follows the literature and measures trust using the trust game (Berg et al., 1995), but in an infinitely repeated fashion and with hidden actions. We borrow the uncertainty component introduced by Charness and Dufwenberg (2006) to the trust game, together with hidden action, and extend the design to an infinitely repeated scenario. Our results indicate the importance of personality traits in determining trust choices, over and above the influence of subjective beliefs. An intuitive explanation for the likely avenue through which personality traits would guide decisions would be the formation and updating of beliefs. Our results suggest that when modeling personality traits into the decision to show trust, we should also consider a sort of 'warm glow' effect as the mechanism that is operating. Additionally, our data suggest that the Agreeableness factor as a whole is not relevant in determining trust choices but rather, it is the specific trust facet that guides people towards more trusting decisions.

The paper is organized as follows: section 1.2 reviews the relevant literature by establishing the importance of personality for economic thought and research, and consequently discussing the important work done on trust. Section 1.3 describes our experimental design and its implementation, section 1.4 presents our results and section 1.5 offers some concluding remarks and discussion.

1.2 Literature Review

There has been increasing support within economics for the view that understanding the implications of personality traits for economic thought is paramount (e.g. Borghans et al., 2008; Rustichini, 2009; Ferguson et al., 2011; Anderson et al., 2011). Almlund et al. (2011) and Ferguson et al. (2011) discuss how personality traits can be seen as 'constraints' on behaviour. In the context of showing trust this can be interpreted as finding that someone who is more agreeable would be more prone to trust others.

There has been a substantial amount of work focusing on the link between personality traits and economic outcomes. Empirical studies have identified effects of personality traits on job performance (Barrick and Mount, 1991; Almlund et al., 2011), occupational attainment (Roberts et al., 2007), and wages (Nyhus and Pons, 2005) as well as on subjective well-being (e.g. Wood et al., 2008; Proto and Rustichini, 2015; Boyce et al., 2010). Additionally, experimental studies have examined the importance of personality traits. Becker et al. (2012) measured the effects that traits have on the trust game, the dictator game and in punishing behavior in a modified prisoner's dilemma game. They show that personality traits measured by the Big Five are weakly correlated with economic preferences (i.e. choices in the different games studied), but *complement* economic preferences in predicting life outcomes. Filiz-Ozbay et al. (2013) study the importance of personality traits on a one-shot gift exchange game and find that individuals with higher Agreeableness scores offer higher wages. These authors note that controlling for intelligence is very important for estimating personality trait effects - they find very biased estimates when omitting cognitive ability from their analysis. Fréchette et al. (2011) find that in choice under ambiguity, personality traits affect the type of information sought and also whether individuals follow any advice they are offered.

Given the importance of trust, many researchers have investigated its determinants. This has been done using both survey and experimental methods - will return to the latter below. Using survey data, Alesina and La Ferrara (2002) identify a variety of key characteristics that determine whether one would be a trusting individual or not. They focus on socio-economic characteristics such as being economically unsuccessful and being part of ethnic minorities that had been discriminated against. More relevant for our purposes, Dohmen et al. (2008) using the German Socio-Economic Panel, are able to link more trusting attitudes with Agreeableness (similar evidence in Becker et al. (2012)). Their evidence is however based on correlating one survey item to another. In our data we try to establish whether incentivized decisions and choices are indeed determined by self-reported personality traits.

Since Berg et al. (1995) there has been much interest in the trust game in economic laboratories. Many studies have identified a variety of characteristics that are important in determining and sustaining trust. Bohnet and Zeckhauser (2004) note the inherent risk involved when trusting others and show that individuals require an additional 'risk premium' to offer their trust. More precisely, they show that expectations of cheating or betrayal, affect the likelihood of showing trust. Butler et al. (forthcomingb) go a step further and estimate that increasing the perceived probability of not being cheated from 0.1 to 0.9 increases the amount transferred in the trust game by 51%. Our results show that when an individual is more inherently trusting, then they are likely to still trust even if they are not very sure about the likelihood of being cheated.

Ashraf et al. (2006) find that expectations of high returns as well as unconditional kindness are important predictors of trust choices in a trust game. Interestingly, they comment on how across their regression specifications, the constant term is significantly positive and how that might reflect trustors deriving satisfaction from the act of trusting itself. This, we believe, can be seen as indirect evidence consistent with our results that indicate the trust facet acts independently from belief formation in determining trust choices. Other characteristics or design features have also been found to help foster greater trust, like intelligence (Burks et al., 2009; Corgnet et al., 2015) and pre-play communication (e.g Charness and Dufwenberg, 2006; Ben-Ner and Putterman, 2009). Butler et al. (forthcominga) provide evidence that trustworthiness can be traced back to parental values instilled during upbringing. It is important to note how different design choices can affect the resulting data and this is exactly what the meta-analysis by Johnson and Mislin (2011) shows. For example, random payment is found to significantly reduce the amounts sent.

Following the example of Berg et al. (1995) most studies have focused on one-shot interactions. Butler et al. (forthcominga) run a repeated trust game experiment, but restrict it to one-shot interactions amongst their subjects. They show that individuals extrapolate their trust beliefs from their own trustworthiness and that this is a relatively stable tendency. Generally, the repeated trust game has been avoided due to concerns about confounding trust choices with reputation and future reciprocation considerations. We argue that trusting behaviour is now established for one-shot interactions; there is abundant evidence of individuals showing trust in one-shot experimental games. Here we examine trusting behaviour in repeated interactions with the same individual. This allows our subjects the opportunity to form a better understanding of the reliability of their partner, rather than only applying their beliefs on the trustworthiness of the general public.

As mentioned, the majority of the literature has examined one-shot interactions of the trust game. There are, of course, some notable exceptions. For example, Engle-Warnick and Slonim (2004) compare the *finitely* repeated trust game with the *infinitely* repeated version. They find that when the end of the game is definite (i.e. finite repetition), the level of trust drops as subjects get more experienced. This is not true when the end is indefinite (i.e. infinite repetition), indicating that concerns for the future help to sustain trust. Our data shows a similar decay of trust choices *within* supergames. In later work, the authors find that longer lasting supergames help sustain higher trust (Engle-Warnick and Slonim, 2006). Other studies have also looked at what can help build trust in repeated games. As might be expected, reputation cues help to increase trust (Boero et al., 2009; Abraham et al., 2015) as well as having information on past actions by the trustee (Bracht and Feltovich, 2009).

Another relevant strand in the literature for our purposes is concerned with trust game experiments that involve hidden actions. Charness and Dufwenberg (2006) added the ingenious twist to the trust game of uncertainty following reciprocation of trust. That is, Nature steps in and determines whether the first player (trustor) receives payment according to some probability. The catch is that the trustor does not receive information on the actions of the trustee and so when receiving 0, cannot know whether this was due to Nature or due to their partner not reciprocating. This seemed to us to be the ideal design to test whether individuals will show trust to others, even without knowing if their trust is being reciprocated. For our purposes, we alter their design from one-shot interactions to an infinitely repeated version and ensure that decisions are made sequentially.[1]

Subjective beliefs are believed to be an important driver for experimental game choices. Importantly, for the trust game, if one believes the second mover will reciprocate then it makes rational sense to show trust and enjoy the spoils. Several studies have indeed found a significant relationship between subjective beliefs and trusting choices (e.g. Bellemare and Kröger, 2007; Sapienza et al., 2013; Costa-Gomes et al., 2014). In our experiment we ask the participants to state their

[1]In their design, second players (trustee) were deciding their action before being informed on the trustor's choice.

expectations of reciprocation from their partners in order to test whether Agreeableness or the trust facet drive the formation of beliefs. Our data seems to suggest that belief formation is independent of personality traits.

Finally, to motivate our hypothesis that more agreeable individuals will trust more, we note some relevant results in the literature. Anderson et al. (2011) analyze the effect of traits on the trust game using a large sample of truck driver trainees and find that Agreeableness increases the amount transfered. Becker et al. (2012) find a positive and significant correlation between average amounts sent in a trust game and Agreeableness and Ben-Ner and Halldorsson (2010) find significant effects on survey-measured trust. Ben-Ner and Halldorsson (2010), however, do not find significant effects of Agreeableness on the amount sent in a trust game. The lack of a significant link, in the trust game variation, could very well be because of their use of the Agreeableness factor, rather than the trust facet that we utilize in our analysis.

1.3 Experimental Design

Participants were partnered with others in the lab and asked to play an infinitely repeated trust game with hidden action. Infinite repetition was induced by introducing a random continuation probability, δ. Participants were randomly and anonymously matched and played the game for five rounds and subsequently a termination of the partnership occurred with probability 0.2 (i.e. $\delta = 0.8$). That is, with 0.8 probability they would continue with the same partner and with 0.2 probability they would stop; but all partnerships lasted *at least* for 5 rounds. The minimum play of 5 rounds per partnership was enforced in order to allow the participants the opportunity to identify whether their partner was trustworthy or not.[2] When partnerships were terminated all participants were again randomly and anonymously re-matched and

[2]Specifically, if the random termination rule only allowed for one or two rounds with one partner, then it would be near impossible for the participants to realistically form any beliefs or understanding about their partner's type.

played the game as before. The matching and repetition was continued up until at least 30 rounds were completed of the stage game. This meant that we kept no time constraint on the time spent on the trust game; the target was to play at least 30 rounds (across supergames). All participants kept the same role in the game throughout. After the instructions were administered, all participants were asked to complete a quiz to ensure their understanding of the game, the repetition and the matching protocols. They were not informed on the length of play to avoid end of game effects as far as possible. The screens of the instructions together with the quiz that was administered are included in appendix B.

1.3.1 The Game

The stage game that was used is the investment game (or trust game) introduced by Charness and Dufwenberg (2006), depicted in figure 1.1. It extends the typical trust game to include a step where Nature comes in and introduces uncertainty about the success of a sequence of moves of trust and reciprocation. Compared to Charness and Dufwenberg (2006), we increase the probability that Nature determines a failure from 1/6 to 1/3. We do this in order to alleviate any concerns that the likelihood of a failure is too low and hence would not be taken into consideration by the participants.

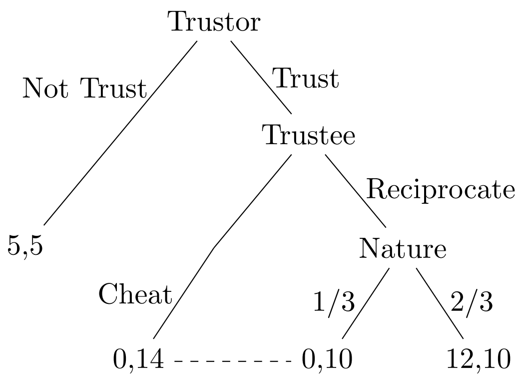


Figure 1.1: **Stage Game:** The Trust Game

This transformed trust game essentially aims to bring trust games closer to a principal agent type scenario. The trustor (principal) decides whether to hire or not the trustee (an employee) to implement a risky project. If the decision is to *Not Trust* (i.e. not hire) they both gain outside option payoffs of 5. If *Trust* is played, then the trustee is given the opportunity to either *Reciprocate* (i.e. work/put in effort) or *Cheat* (i.e. shirk). If the trustee plays *Cheat* then she can enjoy the payoff of 14 (this can be thought of as the hiring wage), while the trustor receives nothing (i.e. the project has not been implemented). If instead the trustee plays *Reciprocate*, she will receive 10 - putting in effort is costly. The payoff for the trustor though, will depend on Nature - the project's success. With probability 2/3 the project is successful and the trustor receives a payoff of 12, while with probability 1/3 the project fails and the trustor receives a payoff of 0. Note that the explanation and exposition of the game during the sessions was done in a non-loaded manner. That is, the words trust, hire, cooperate, shirk and so on were never used and instead simple alphanumeric labels were given for both players and actions in the game.[3]

Despite the introduction of the Nature step, the typical subgame perfect equilibrium solution of one shot trust games is preserved. That is, $(Not\ Trust, Cheat)$ is the backwards induction solution of the game. This of course is an inefficient outcome since both players would be better off in the case of a project being successful after there has been trust and the trustee reciprocated. The infinite repetition that is induced for the game actually allows for $(Trust, Reciprocate)$ to be sustained as an equilibrium outcome for the game.[4]

The critical characteristic of this game is that the actions of the trustee are non-observable by the trustor. That is, whenever the trustor receives a payoff of 0, she does not know whether this was the result of the trustee cheating or Nature

[3]A snapshot of the way the game was presented on the participants' screen is in appendix B, figure B.8 for the trustor and B.9 for the trustee. Note how in B.9 there is a note on the decision made by the trustor (Player 1), i.e. decisions were made sequentially.

[4]In fact, as long as the game is repeated by a probability greater than 0.5 then $(Trust, Reciprocate)$ can be sustained as an equilibrium. In our case we have delta=0.8 which thus allows for trust and reciprocation to be part of equilibrium strategies.

destroying their payoff. At the end of each round, participants playing as trustors were informed of their payoff for that round, while also being reminded of their action choice. They were never informed of the action choices by the trustee. This essentially helps to test one's trust in a much stronger way than is possible in typical one-shot trust games. A trustor that receives 0 will know that two events could have taken place. If one tends to be a more trusting individual then one is more likely to give their partner the benefit of doubt. Meaning that they would be more likely to believe that what has transpired is that their partner has in fact reciprocated but Nature destroyed their payoff.

Important to note is that we chose not to use the strategy method because it was very important for our design that the trustor felt the direct repercussions of the trustee's decisions. Also, the realisation of Nature and length of each supergame was left to be random for each session. After each decision made by participants playing as trustor, we also asked them to give us their belief about the likelihood that their partner will reciprocate. This was incentivised and paid according to a quadratic scoring rule. It is generally accepted that a quadratic scoring rule will give individuals the incentive to truthfully report their subjective beliefs. This is true when assuming risk neutrality and is one of the criticisms that Schotter and Trevino (2014) note. Given the lack of reliable non-intrusive alternatives and in accordance with the majority of the literature, we opted to use the quadratic scoring rule. Specifically, for each belief elicitation stage participants were able to earn an additional experimental unit following function 1.1 below. $\hat{r}$ is a participant's stated belief of the likelihood of the trustee reciprocating (this was stated as a number probability between 0 and 100 in increments of 5) and r is the actual choice made by the trustee (0 if cheat, 100 if reciprocate).

$$Beliefs\ Earnings = 1 - \left(\frac{\hat{r}}{100} - \frac{r}{100}\right)^2 \tag{1.1}$$

Each experimental unit corresponded to 0.015 GBP.

1.3.2 Other tests and measures

The participants were asked to complete a Big Five personality questionnaire. We used the IPIP-NEO-120 inventory which is based on 120 questions with answers coded on a Likert scale. This inventory was developed by Johnson (2014). We chose this particular inventory because it offered the opportunity to measure the Big Five factors as well as the various facets of each factor. This would not have been possible had we used a shorter Big Five questionnaire. Additionally, time constraints for the sessions were an issue and so we elected to use this inventory rather than the IPIP-NEO (Goldberg, 1999) or the NEO PI-R (Costa and McCrae, 1992) which are much longer. For our purposes we focus on *Agreeableness* (the factor) and the *trust facet* within Agreeableness. The trust facet is one of six facets that the factor of Agreeableness is broken into. The others are: morality, altruism, cooperation, modesty and sympathy. A full list of all the questions and the corresponding facet for each are included in appendix A.[5]

In order to collect measures of reasoning ability and general intelligence, the participants were asked to complete a Raven Advanced Progressive Matrices (APM) test. The Raven test is a non-verbal test and was chosen for exactly this reason as it allows measurement of an individual's intelligence without distortions due to math or language skills. The participants were asked to complete 30 patterns with 30 seconds allowed per each one. Before the test was initiated, the subjects were shown a table with an example of a matrix with the correct answer provided for 45 seconds. For each pattern a 3×3 matrix of images was displayed on the subjects' screen; the image in the bottom right corner was missing. The subjects were then asked to complete the pattern by choosing one out of eight possible choices presented on the screen. The 30 tables were presented in order of progressive difficulty and

[5]When the questionnaire is administered the questions are not grouped by facet or factor. All items are presented in a random order.

were selected from Set II of the APM. A random choice of three patterns was chosen and paid by £1 if correct. The Raven's test is not usually incentivised with money but we chose to reward the task in order to avoid any potential confounding with motivation.

The participants were also asked to complete an incentivised Holt-Laury task to measure risk attitudes.

1.3.3 Order & Questionnaire Incentivising

In order to ensure that playing the trust game or responding to the Big Five questionnaire did not have any spillover effects to each other, we varied the order in which the participants were asked to complete tasks across sessions. Participants either started by playing the trust game or by responding to the questionnaire. Table A.1 in appendix A details the two different timelines that sessions conformed to.

Finally, from session 5 until session 11, we offered an incentive for participants when responding to the personality questionnaire. Specifically, before they responded to the questionnaire we informed the participants that we would be providing them with the psychometric scores to the various questions they would be responding to.[6] This was implemented to provide incentives for truthful responses.

1.3.4 Implementation

We conducted a total of 11 sessions with 182 participants. 91 played as Trustors and 91 as Trustees.

All the participants were recruited from the subject pool of the Warwick experimental laboratory. The recruitment was conducted with the DRAW (Decision Research at Warwick) system, based on the SONA recruitment software. The dates

[6] Please refer to the paragraph before 'START QUESTIONNAIRE' in the script that was used that is included in appendix A for the exact instruction used. A sample snapshot (figure A.1) of the way the scores were provided to the participants is also included in appendix A together with the email that was sent to very briefly explain the different scores.

of the sessions and the number of participants per session are in Appendix A in table A.2.

The subjects earned on average 12.28 GBP (about 19 USD); the show-up fee was 5 GBP. The software used for the entire experiment was Z-tree (Fischbacher, 2007). The Ethical Approval of this design was granted by the Humanities and Social Sciences Research Ethics Sub-Co at the University of Warwick under DRAW Umbrella Approval (Ref: 86/14-15:DR@W).

1.4 Results

In order to first confirm that there are no spillover effects from the questionnaire to choices in the trust game or vice versa, we test whether there are any order effects on the choice of the first round of the trust game. The t-test confirms that there are no ordering effects, i.e. the null of no difference across the two orders is not rejected ($p-$ value $= 0.5668$). We also test whether the trust facet appears to have any difference across the different orders implemented. Again the null of no difference is not rejected ($p-$ value $= 0.4006$). Since there were no ordering concerns in the subsequent analysis all sessions are aggregated together irrespective of the order used for each session.[7] In order to make the reading of the results more comprehensible and comparable across variables we normalised the personality, risk preference, ability and belief variables to be in the range of $(0,1)$. This is done by identifying the minimum and maximum for each variable and then using formula 1.2 below.

$$x_i^{norm} = \frac{x_i - x_{min}}{x_{max} - x_{min}} \tag{1.2}$$

Table 1.1 shows the mean characteristics of the subjects in the sample split by the role they played. No characteristics were statistically different at the 5% sig-

[7]We also test whether the personality incentivisation implemented had any effect on trust choices in the game. The null of no difference was not rejected ($p-$ value $= 0.7307$)

nificance level indicating that the randomised allocation of roles within each session did not result in any selection-related confounds.

Table 1.1: **Differences in main variables across roles.**

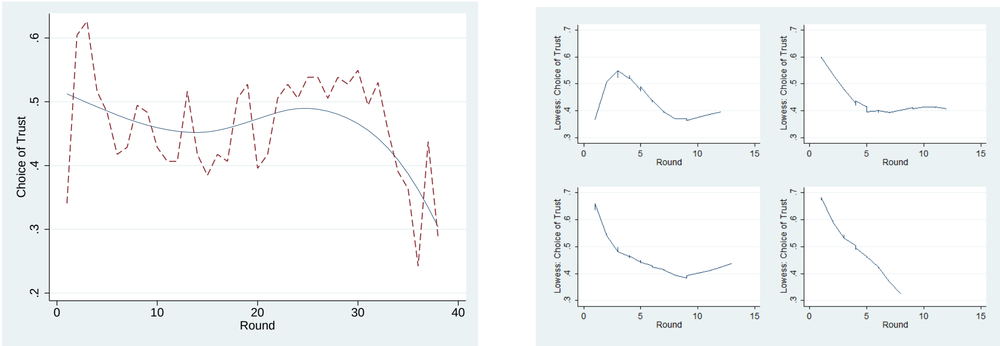
Variable	Trustors	Trustees	Differences	Std. Dev.	N
Age	22.14	21.64	.52	.75	182
Female	.56	.57	-.01	.07	182
Openness	3.41	3.39	.03	.08	182
Conscientiousness	3.70	3.57	.13*	.08	182
Extraversion	3.31	3.35	-.03	.07	182
Agreeableness	3.72	3.66	.06	.07	182
A: Trust	3.51	3.52	-.01	.12	182
Neuroticism	2.83	2.93	-.10	.08	182
Raven	17.01	16.56	.45	.55	182
Risk Aversion	.56	.54	.02	.03	182
Final Profit	169.90	271.26	-101.36***	5.41	182
Periods	33.88				182

Note: The variables are merged across all sessions. * $p-value < 0.1$, ** $p-value < 0.05$, *** $p-value < 0.01$.

1.4.1 Trust trend

As a first look at the data, figure 1.2a graphs the choices to trust across all rounds and sessions. The dotted line in figure 1.2a is the mean choice for each round and the solid line is the lowess estimator. The pattern we see in the figure is what one would expect. Trust is played with a proportion of just over 0.50 in the beginning of play and gradually reduces as play progresses. Figure 1.2b splits the trust choices by supergames and the familiar picture of initial trust and eventual decay of trust within each supergame is clear. These trends in trusting behaviour across rounds are similar to what previous literature has shown with regards to the evolution of trust in repeated interactions (e.g. Engle-Warnick and Slonim, 2004).

We then separate individuals by their self-reported trust attitudes and their choices in the game across rounds as well as by their risk preferences. Figure 1.3a shows the average choice to trust, by splitting the sample by the median in the

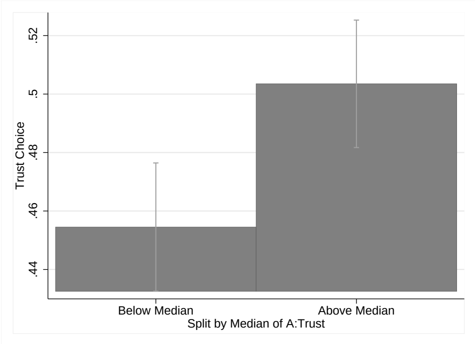


(a) Across all Rounds (b) By Supergame

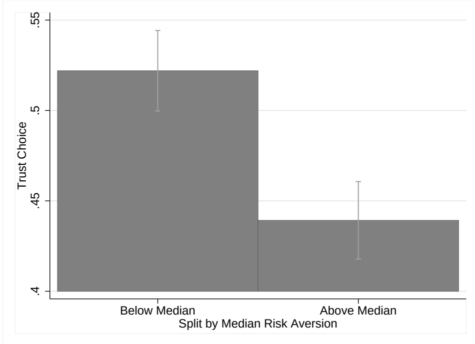
Figure 1.2: **Trust per period across all individuals and sessions.**
The dotted line represents the mean choice of trust and the solid lines represent the lowess estimator for the trust choice across rounds.

trust facet of Agreeableness across all interactions. There is a significant difference in the average choice to trust between the two groups, such that the more trusting individuals choose trust more often. Figure 1.3b again displays the average choice of trust across rounds but now split according to median risk preferences. In this split one can clearly see how those below median (i.e. less risk averse) are on average significantly more likely to choose to trust. In figure 1.4 we depict the trend across rounds in choices of trust. It is apparent that the individuals who scored higher in the trust facet are always above those scoring lower in terms of likelihood to show trust. Also, individuals who are more risk averse are always trusting less than those who are lower on the risk aversion measure. Thus, without controlling for any other characteristics we can see how there seems to be a pattern that makes trusting individuals more likely to play trust and those who are more risk averse less likely to trust.

The above effect is tested in the regression analysis presented in table 1.2. This is a random effects probit estimation of the choice to trust across all rounds. Focusing on the first column, one can see that after controlling for all other characteristics (including risk preferences), the trust facet of Agreeableness is significant at 5% and has a marginal effect of 25% on the decision to trust. In column 2 we include Agreeableness in the estimation which causes the trust facet to lose signifi-

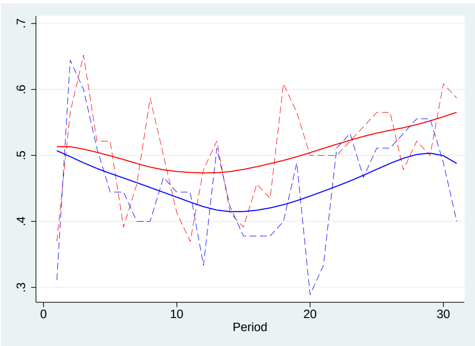


(a) By A:Trust

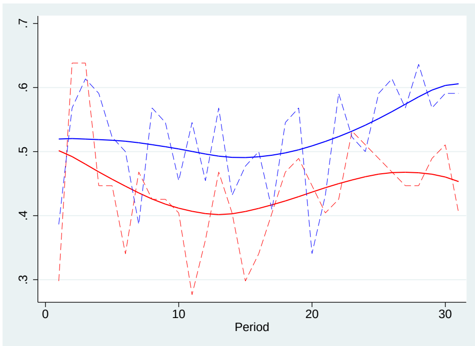


(b) By Risk Aversion

Figure 1.3: **Average Trust Choice**
The histograms represent the average choice of trust after splitting the sample by the median of each characteristic. The bands represent the 95% confidence intervals.



(a) By A:Trust



(b) By Risk Preferences

Figure 1.4: **Trust per period in aggregate.**
The red solid lines represent lowess estimator for the individuals above median in each characteristic and the blue solid lines represent the lowess estimator for the individuals below median. The respective dotted lines represent mean choices.

cance (still significant at 10%) but the marginal effect goes up. Important to note is also the effect of risk aversion across all specifications. As expected, the more risk averse individuals are, the more likely they will be to not trust in the game. This is a quite strong effect indicated by the approximately 30% marginal effect.

The fact that the effect of the trust facet remains after controlling for risk preferences, indicates the importance of individual heterogeneity that can be attributed to personality. It signifies the fact that trust is a relevant attribute of people and appears easily measurable through a simple survey questionnaire. Interestingly, Agreeableness as a whole factor on its own does not appear to influence the decision to trust. This is clear from the estimated model in column 3 of table 1.2 where the same model as in column 1 is estimated but using Agreeableness (the factor) instead of the trust facet. This evidence suggests that when trying to investigate potential personality effects, it is important to think carefully about whether specific facets will be the relevant characteristic rather than the broad aggregated factors. Notice that had we implemented the analysis focusing solely on Agreeableness we would have concluded that personality appears to be irrelevant for the decisions in the infinitely repeated trust game.

Result 1.4.1. *The trust facet and risk preferences are both important predictors of the trust choice with marginal effects around 21% and 30% respectively. Agreeableness as a whole factor appears to not be a significant influence on the choice to trust in the infinitely repeated trust game.*

In the existing literature on trust games the importance of subjective beliefs for the subjects' decisions is widely reported. In this part, we include the stated beliefs in the analysis to consider whether the personality effect identified above is driven through belief formation.

The resulting regressions, after controlling for subjective beliefs, are presented in columns 4 and 5 of table 1.2. By focusing on column 4 one can see that the effect of the trust facet is still statistically significant even after controlling for beliefs. The facet effect does lose significance to some extent (the $p - value$ before including beliefs is 0.045 and after including beliefs is 0.058), but importantly the change is quite minimal while the marginal effect remains at similar levels. Column 5 again tries to investigate whether Agreeableness as a whole can be a predictor for trust choices and once again one can see that the whole factor seems to be insignificant at standard significance levels. Subjective beliefs of the participants are indeed found to be strongly significant and have a constant marginal effect of around 50%.

Given the apparent independent effect on trust choices of the trust facet and of subjective beliefs in table 1.2 we try to identify whether the trust facet

Table 1.2: **Trust Choices**: Panel random effects estimation of probit model.

	(1)	(2)	(3)	(4)	(5)
Stated Beliefs				0.5065***	0.5133***
				(0.0926)	(0.0926)
Openness	0.1659	0.1835	0.1728	0.1212	0.1208
	(0.4959)	(0.5038)	(0.5137)	(0.4640)	(0.4789)
Conscientiousness	–0.0541	–0.0460	–0.0486	0.0006	0.0015
	(0.4271)	(0.4287)	(0.4372)	(0.3994)	(0.4072)
Extraversion	–0.1950	–0.2252	–0.1006	–0.2317	–0.1485
	(0.5894)	(0.6148)	(0.5978)	(0.5504)	(0.5562)
Agreeableness		–0.0883	0.1291		0.1393
		(0.5345)	(0.4150)		(0.3867)
A:Trust	0.2541**	0.3058*		0.2211*	
	(0.3636)	(0.4769)		(0.3403)	
Neuroticism	0.1695	0.1599	0.1926	0.2006	0.2204
	(0.7149)	(0.7170)	(0.7284)	(0.6685)	(0.6783)
Raven	–0.1499	-0.1616	–0.1475	–0.1814	–0.1767
	(0.4795)	(0.4842)	(0.4937)	(0.4471)	(0.4583)
Female	–0.0438	-0.0367	-0.0522	–0.0638	–0.0731
	(0.2009)	(0.2055)	(0.2078)	(0.1876)	(0.1932)
Age	0.0005	0.0007	0.0006	–0.0041	–0.0043
	(0.0175)	(0.0175)	(0.0178)	(0.0163)	(0.0166)
Risk Aversion	–0.3062**	–0.3064**	-0.2677*	–0.3387**	–0.3065**
	(0.5065)	(0.5060)	(0.5130)	(0.4740)	(0.4782)
Last Payoff	0.0246***	0.0245***	0.0246***	0.0203***	0.0203***
	(0.0066)	(0.0066)	(0.0066)	(0.0068)	(0.0068)
Accumulated Profit	–0.0005***	–0.0005***	–0.0005***	–0.0004**	–0.0003**
	(0.0017)	(0.0017)	(0.0017)	(0.0017)	(0.0017)
Repeated Game	0.0309***	0.0317***	0.0293***	0.0289***	0.0270***
	(0.0666)	(0.0666)	(0.0667)	(0.0686)	(0.0687)
Round within SG	–0.0316***	–0.0316***	–0.0314***	–0.0278***	–0.0276***
	(0.0095)	(0.0095)	(0.0095)	(0.0098)	(0.0098)
Session FEs	Yes	Yes	Yes	Yes	Yes
Individuals	91	91	91	91	91
N	3083	3083	3083	3083	3083

Note: The dependent variable is the choice of trust per individual. Reporting marginal effects at means and in brackets the standard errors. * $p-value < 0.1$, ** $p-value < 0.05$, *** $p-value < 0.01$.

has any effect on the belief formation of our participants. Column 1 of table 1.3 presents the results of a random effects panel regression of subjective beliefs in each round on the various individual characteristics we have been considering as well as the game experience variables we have been using in the analysis throughout. It appears that none of the individual characteristics are important in predicting the subjective beliefs of the participants other than age (only at 10% significance).

From these regression results it seems clear that an individual's own inclinations are not important in how their beliefs are formed as the game is played - at least in the repeated set-up. Columns 3 and 4 of table 1.3 report analysis of only the first rounds of each supergame and the first round respectively with similar results. It seems that what matters is the experience a player has had up until a particular belief formation step. This is an unexpected result, as in general in economics one would expect that different personality effects could potentially be explained through the formation of beliefs. It would appear though that the trust facet operates independently to belief formation in guiding trust choices, indicating that perhaps more trusting individuals simply gain extra satisfaction through the act of trust.

Result 1.4.2. *The trust facet of Agreeableness is still a significant predictor of trust choices even after controlling for subjective beliefs. The trust facet appears to operate independently from belief formation.*

1.4.2 Mechanism for Trust

In this part we try to identify the mechanism that leads more trusting individuals towards more frequent trust choices in the repeated trust game. We compute a variable that we call *Benefit of Doubt*. This is a binary variable that is equal to 1 whenever a subject decides to play trust after receiving a payoff of 0 in the previous round and equal to 0 otherwise. We call it benefit of doubt, as when players decide to trust after receiving 0 it would appear likely that they consider the previous round payoff to be due to Nature destroying their payoff rather than their partner not reciprocating their trust. In figure 1.5 we split the sample by the median on the trust facet and compute the average times the two groups offered the benefit of doubt. There is a significant difference between the two; individuals above median in the trust facet offer the benefit of doubt significantly more often.

In table 1.4 we estimate the magnitude of the effect of the trust facet on the likelihood to be offering the benefit of doubt. Column 1 indicates how the

Table 1.3: **Subjective Beliefs:** Panel random effects estimation.

	Whole Panel (1)	Whole Panel (2)	First Rounds (3)	First Period (4)
Openness	11.2754	13.3582	7.8251	–9.0394
	(13.4472)	(13.7680)	(13.8064)	(19.2086)
Conscientiousness	–11.1881	–10.1269	–3.0553	–12.1157
	(11.6456)	(11.7858)	(11.9090)	(16.6429)
Extraversion	5.0767	7.8251	–0.7468	5.4414
	(16.1067)	(16.1374)	(16.3587)	(23.0213)
Agreeableness		–0.2140		
		(11.1532)		
A:Trust	10.8117		8.3295	–4.5401
	(9.8648)		(10.0709)	(14.0897)
Neuroticism	–6.3646	–5.6329	–6.2489	–0.6341
	(19.4518)	(19.5918)	(19.9227)	(27.7934)
Raven	6.4386	5.3330	25.1645*	–18.8556
	(13.0067)	(13.2378)	(13.3664)	(18.5964)
Female	4.6514	4.7742	1.3054	–6.3461
	(5.4813)	(5.6049)	(5.5930)	(7.8335)
Age	0.9180*	0.9470**	1.2191**	–0.0312
	(0.4783)	(0.4830)	(0.4875)	(0.6835)
Risk Aversion	–2.4493	–0.4823	1.6538	16.2423
	(13.7713)	(13.7887)	(14.1109)	(19.6744)
Last Payoff	1.0740***	1.0744***		
	(0.1259)	(0.1259)		
Accumulated Profit	–0.1929***	–0.1930***	0.2050***	
	(0.0325)	(0.0325)	(0.0783)	
Repeated Game	7.1155***	7.1189***	–9.6818***	
	(1.3055)	(1.3057)	(3.1540)	
Round within SG	–1.3192***	–1.3194***	0.0000	
	(0.1840)	(0.1840)	(.)	
Session FEs	Yes	Yes	Yes	Yes
N	3083	3083	398	91
Individuals	91	91	91	

Note: The dependent variable is the subjective beliefs per individual on the likelihood of the trustee to reciprocate. The first two columns are estimated for the whole panel. Column 3 is estimated for the first round of each supergame and lastly column 4 is only estimated for the first round played. Reporting coefficients and in brackets the standard errors. * $p-value < 0.1$, ** $p-value < 0.05$, *** $p-value < 0.01$.

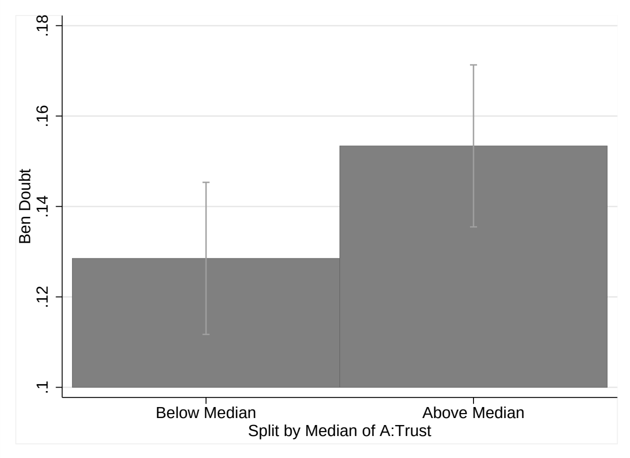


Figure 1.5: **Average Benefit of Doubt by A:Trust.**
The histograms represent the average benefit of doubt given after splitting the sample by the median of A:Trust. Benefit of doubt is equal to 1 whenever a subject decided to trust after in the previous round they received payoff of 0. The bands represent the 95% confidence intervals.

Table 1.4: **Benefit of Doubt:** Panel random effects estimation of probit model.

	(1)	(2)	(3)	(4)
Stated Beliefs			0.1217***	0.1209***
			(0.1055)	(0.1056)
A:Trust	0.1078**	0.1338**	0.0963**	0.1106*
	(0.3197)	(0.4183)	(0.3041)	(0.3981)
Char. Controls	Yes	Yes (incl. A)	Yes	Yes (incl. A)
Exp. Controls	Yes	Yes	Yes	Yes
Session FEs	Yes	Yes	Yes	Yes
Individuals	91	91	91	91
N	3083	3083	3083	3083

Note: The dependent variable is the decision to trust after receiving 0 in the previous round. Reporting marginal effects at means and in brackets the standard errors. The same individual characteristic controls as in table 1.2 are included as noted. Experience controls refer to variables accounting for length of play and earnings up until each round. We exclude all other characteristics and experience controls from the table as they were not found to be significant in any of the specifications estimated. $^{*}\ p-value < 0.1$, $^{**}\ p-value < 0.05$, $^{***}\ p-value < 0.01$.

main motivator in giving the benefit of doubt is the trust facet of Agreeableness. Even after controlling for subjective beliefs one can see how the trust facet remains significant at standard significance levels. Both in columns 1 and 3, the trust facet is significant at the 5% significance level and has a marginal effect of around 10%.

Every other characteristic that is used in the estimation is not found to be significant, while the marginal effect estimated for subjective beliefs is of comparable magnitude to the effect found for the trust facet (around 12%). These results seem to suggest that more trusting individuals are converging towards the trust equilibrium of the game because of their more forgiving nature.

Table 1.5: **Proportion of Ben. of Doubt:** OLS regression results.

	(1)	(2)	(3)
Openness	0.1596	0.1852	0.1796
	(0.1876)	(0.1912)	(0.1987)
Conscientiousness	–0.1162	–0.1052	–0.1065
	(0.1610)	(0.1622)	(0.1685)
Extraversion	–0.2567	–0.3046	–0.1368
	(0.2209)	(0.2306)	(0.2295)
Agreeableness		–0.1518	0.1800
		(0.2021)	(0.1597)
A:Trust	0.3696***	0.4578**	
	(0.1372)	(0.1809)	
Neuroticism	0.1279	0.1634	0.2192
	(0.2742)	(0.2760)	(0.2858)
Raven	0.1279	0.1097	0.1117
	(0.1836)	(0.1858)	(0.1931)
Female	–0.0704	–0.0582	–0.0804
	(0.0758)	(0.0778)	(0.0803)
Age	–0.0049	–0.0045	–0.0047
	(0.0065)	(0.066)	(0.0068)
Risk Aversion	–0.2162	–0.2153	–0.1740
	(0.1892)	(0.1898)	(0.1965)
Session FEs	Yes	Yes	Yes
R squared	0.2318	0.2382	0.1654
N	88	88	88

Note: The dependent variable is proportion of times the benefit of doubt was offered out of the times received payoff of 0 per individual. Reporting regression coefficients and in brackets the standard errors. * $p-value < 0.1$, ** $p-value < 0.05$, *** $p-value < 0.01$.

An issue with the regressions reported in table 1.4 is that we are not exactly testing the frequency at which the participants gave the benefit of doubt, but instead the likelihood that they would. An alternative analysis would examine whether being a more trusting individual actually means that you will offer the benefit of doubt more often. In table 1.5 we regress the proportion of times an individual gave the benefit of doubt over the times they had the opportunity to do so on the same regressors as in table 1.4. In column 1 the trust facet is significant at 1% and actually shows how being more trusting translates to an increase of 37% in the proportion of times one would offer the benefit of doubt. The effect survives the inclusion of Agreeableness in the estimation in column 2, while Agreeableness as a whole factor cannot explain any of the variation in the proportion of offering the benefit of doubt - column 3. Importantly, the trust facet is the only variable that explains the proportion of benefit of doubt offered.

Result 1.4.3. *The trust facet operates through individuals being more forgiving. Trusting individuals are more likely to offer the benefit of doubt and do so in a higher proportion of the opportunities they have to do so.*

1.5 Concluding Remarks

This paper set out to study the link between personality and trust choices in an infinitely repeated trust game with hidden action. Life is filled with many repeated interactions and hence understanding what drives people to trust in repeated games is an important question. What is more, the pertinent question is when will people trust even if they cannot be sure if they are faced with reciprocation or not.

Our results show the importance of personality for inter-personal or social interactions. The trust facet of Agreeableness is found to explain offers of trust by individuals. Importantly, the factor Agreeableness is not supported by our data to be the relevant characteristic, rather the precise facet of trust within Agreeableness was influential.

The unexpected finding in the paper is the independence of the trust facet effect from subjective beliefs. It appears that the decision to trust by individuals who are higher on the trust facet scale is due to some feel good factor, or a 'warm glow' effect of the act of trust. The intuitive way to build personality traits in strategic decision making models would have been within belief formation. Our results seem to suggest that - at least for trust choices - this would be erroneous. In fact, modeling trust decisions of trusting individuals would require one to consider perhaps an additional level of utility due to the mere act of trust. These results are consistent with Kosfeld et al. (2005) where they find evidence that suggest a biological basis of trusting behaviour.

We study a potential mechanism that could be at work in leading individuals higher on the trust facet to trust more. We find that trusting individuals are more likely to offer the benefit of doubt and indeed do so with greater frequency. This forgiving nature of inherently trusting individuals is what eventually leads them to be trusting more in the overall trust game that has been implemented. This is consistent with the assertions made by Nettle (2006) about agreeable individuals being generally more pro-social and trusting individuals. In our data we though find no difference in earnings between participants that trust more or less. This is due to the random determination of payoffs following the reciprocation of trust. That is, our game structure does not allow for great differences to emerge in the earnings of those trusting or not. Future work should focus on allowing for greater difference between the outcomes of not trusting and trusting and thus allowing for the possibility of identifying any potential differences in eventual earnings between trusting and non-trusting individuals. An issue with such an exercise would be the different potential strategies that could be implemented by the second players (trustees). Whether there would be an eventual difference in earnings would also depend on the amount of reciprocation that would take place on the trustee's side.

Overall, our evidence provides support for the importance of personality traits in economics. The results we have presented indicate how easy it can be to identify more forgiving and trusting individuals with four simple questions. During recruitment many firms implement personality questionnaires to identify a good fit for the position to be filled and our results support this practice by indicating how traits can be significant in guiding actions or decisions of individuals.

Chapter 2

Personality as a Skill: Evolving Compositions of Personality Traits

2.1 Introduction

Why do people have different personalities, and why do some individuals appear to have more strongly characteristic, or pronounced, personalities than others? How do different compositions of personality types in a society affect that society's welfare? What are the consequences if the jobs available in a society are more suited to people at one end of the personality distribution?

In this paper we combine approaches to the study of personality from economic and evolutionary psychology to address these and related questions. We make some steps towards a quantitative formulation of important aspects of personality variation both within and between individuals. In doing so, we go beyond the assumption - implicit in most of the existing literature - that an individual's personality can be captured as a single point in a multidimensional space (where the dimensions of the space are personality traits and/or facets). We argue for two related propositions. First, we argue that personality can usefully be regarded as a type of skill. Second, we argue that an individual's location along a personality dimension is best regarded as a distribution rather than a single point. These two assumptions allow us to put the relationship between personality, everyday activity, and well-being on a quantitative footing and to characterise the mismatch between individuals and personality-relevant features of the environments they inhabit.

The paper is structured as follows. After a brief description of contrasting approaches to personality in different disciplines, we outline our own approach, which takes elements from various traditions. We then introduce our three key assumptions. First, drawing on recent research in economics, we argue that personality can for many purposes usefully be viewed as a skill, or 'relative ability' (e.g. Almlund, Duckworth, Heckman and Kautz, 2011), such that particular personality types are able to take better advantage of particular opportunities in the environment. For example, an extravert may be more efficient as a salesperson than an introvert, in that the extravert may achieve more sales for the same level of effort. Second, and based on research from both psychology and the economics of preference and attitudes, we argue that an individual's location along the personality dimension is best characterized as a distribution rather than a single point. This allows us to capture the intuition that some people have more 'specialised' personalities than others. Third, we bring together the first two assumptions to argue that an important component of subjective well-being can be understood in terms of a mismatch between the demands currently facing an individual and their personality. This assumption is motivated both by work in occupational and organizational psychology (e.g., research suggesting that well-being as a function of personality-job mismatch) and by research within psychology (Holland, 1997; Larson, Rottinghaus and Borgen, 2002; Barrick, Mount and Gupta, 2003; Furnham, Petrides, Tsaousis, Pappas and Garrod, 2005).

Within psychology, it has been traditional to see a personality trait as a pattern of behaving, thinking and feeling that is consistent across situations (e.g. Allport, 1961). Beginning with lexicographic approaches, psychologists initially took an essentially descriptive approach with the aim of characterizing a hierarchical structure of meta-traits, traits, and facets within which individuals can be located. Partly as a result of the person-situation debate (Mischel, 1968; Epstein, 1979) it is only relatively recently (in the context of a long history of psychological research on personality and individual differences) that psychologists have returned to the task of examining how well an individual's personality predicts their real-world behavior. For example, the recent meta-review by Roberts et al. (2007) summarizes research showing that the 'Big Five' personality measures (Goldberg, 1993; McCrae and Costa, 1987) typically do as well as cognitive or socio-economic variables in predicting life outcomes such as occupational success and longevity. With the exception of important work by evolutionary psychologists (e.g., Buss, 2009; Nettle, 2006), psychologists have paid relatively little attention to the question of why personality variation should exist in the first place and why it should take the form that it does. Moreover, and again with some noteworthy exceptions (Epstein, 1979; Fleeson, 2001, 2004), it has been implicit in the predominant factor-analytic approaches to personality that single-point measures are appropriate.

Within economics, attitudes towards risk and the future have been measured and used to predict actual behavior rather in the same way as psychologists have treated personality traits, although with more emphasis on quantitative formulation. Although economic researchers tend to talk in terms of *attitudes* towards risk, the intended reference is to a stable and enduring characteristic of an individual that is assumed to apply across contexts (*situations*). Indeed, much recent work in the economics of personality has involved combining 'Big Five' measures of personality with more traditional economic measures such as risk attitude and loss aversion (e.g. Anderson, Burks, DeYoung and Rustichini, 2011; Burks, Carpenter, Goette and Rustichini, 2009).

Economists have also been concerned with questions of how responses to economic interventions might depend on personality, and with how effects of economic variables on well-being may be moderated by personality variables (e.g. Borghans, Duckworth, Heckman and Ter Weel, 2008; Bowles, Gintis and Osborne, 2001a,b). Similar approaches are now becoming more common in psychology as well. For example, Boyce and Wood (2011) show that the marginal effect of income on utility (proxied by subjective well-being) is greater for individuals who score highly in conscientiousness. However, despite a considerable convergence between the approaches of economists and psychologists in the study of personality and its effects on real-world outcomes, economists have been more inclined to develop rigorous quantitative formulations of personality-related concepts.

Finally, evolutionary and ecological approaches to the study of behavior in non-human animals have long studied the conditions under which personality-like differences exist (e.g. Trivers, 1971; Dingemanse and Réale, 2005), and recent research has aimed to show how such approaches may also be applied to the human case (e.g. Gosling, 2001; Buss, 2009; Nettle and Penke, 2010). Nettle (2005, 2006) provide two examples of where this route has been taken. He suggests that the variation of personality can be understood in terms of the trade-offs that exist for being too extraverted, or too neurotic, and so on. Michalski and Shackelford (2010) also suggest that the different levels of Big Five traits that people possess reflect the fact that different strategies are better suited for different contexts. For example, the clear qualitative adaptive difference between mate selection and food selection is proposed to have selected for qualitatively different sets of psychological mechanisms.

Frequency-dependent selection is a special case of heterogeneous selection. It can be defined as the selection that occurs when the fitness outcome of a phenotype or strategy depends on its frequency in the population relative to other phenotypes or strategies (Rèale and Dingemanse, 2010). Our approach lies within a frequency-dependent selection framework, in the sense that similar agents compete for particular tasks and not all agents can survive if not enough tasks exist.

We approach the problem with a simple agent-based model simulation (ABM). ABMs have a long tradition of being applied to a variety of social issues focusing for example on how group-level structures can be the result of individual actions, preferences or abilities. ABMs can facilitate integration of cognitive, social and evolutionary approaches (see: Goldstone and Janssen, 2005). They have been used in evolutionary psychology to illustrate the effect of dynamic interplay between individuals that follow well-specified decision rules (e.g. Kenrick, Li and Butner, 2003). There is also work within economics that utilises various computational methods (see: Kendrick, Mercado and Amman, 2006).

The first critical assumption of our approach is that an individual's personality can be regarded as a skill. This way of thinking is similar to the approach taken by Almlund et al. (2011). They argue that personality can be viewed as one of many individual characteristics that can have important implications for an individual's productivity (or efficiency) at particular tasks or jobs. The important link between personality traits and occupational attainment has also been reviewed by Roberts et al. (2007) who find that personality traits are only rivalled by intelligence scores as a predictor of occupational attainment. Roberts et al. (2007) find that various socio-economic factors as well as parental income are less important in predicting an individual's job attainment than are personality traits. Similar findings can also be found in Anderson et al. (2011) who show how job persistence can be better predicted by personality traits than by standard economic preferences (i.e. risk preferences and time preferences). Furthermore, Nyhus and Pons (2005) discuss how different personality traits can have varying effects on earnings, which can be seen as an implication of our approach in regarding personality partly as an individual's skill.

The second critical assumption of our approach is that an individual's personality can be regarded as a distribution rather than a single point. Although related suggestions have appeared in the literature (e.g. Heller, Komar and Lee, 2007; Fleeson, 2001) it has not been the norm in personality research. Fleeson (2001) focuses on the extraversion trait and presents results that shed light on the high within-person variability in behaviours during the course of daily life over about 3 weeks. It is also suggested that behavioural variability is a stable individual difference. In later work, the importance of switching the focus from single point to distributional measures of personality has sometimes been discussed. It has been argued to be relevant to resolving the person-situation debate (Fleeson, 2004) and also to understanding the implication of individuals not acting in an authentic manner, i.e., 'being themselves' (Fleeson and Wilt, 2010). We take a further step and consider how not being able to perform tasks that 'fit' your personality has potential detrimental effects on your subjective well-being and, perhaps, consequently on your productivity.

The relevance of personality to well-being has been widely documented. For example, Wood, Joseph and Maltby (2008) show how personality traits (measured by the Big Five) can explain between 25% and 35% of the variation in subjective well-being depending on whether one uses the factors or the facets in the analysis. Additionally, Proto and Rustichini (2015) and Boyce, Wood and Brown (2010) find evidence of the importance of personality on well-being. A potential mechanism that can explain the link between personality and subjective well-being is job match - or mismatch. The study of individual characteristics and job matching has been quite prominent in personnel psychology and management studies. Judge and Cable (1997) show that job seekers' personality traits guide their job search. Additionally, Gardner et al. (2012) provide evidence that different personality traits will have different perceived fits in different organisational cultures - e.g. more conscientious individuals are found to perceive themselves to fit better in a hierarchical culture. Generally the literature has mostly focused on personality and perceived job matching and on personality and job performance (e.g. Barrick and Mount, 1991; Barrick, Mount and Judge, 2001). The link between personality and job satisfaction has not received much attention (with some exceptions: e.g. Judge, Heller and Mount, 2002; Furnham, Eracleous and Chamorro-Premuzic, 2009) and with this present paper we offer a specification of the underpinning mechanism that could help foster future work in investigating any such links.

Our approach in modelling job matching with respect to personality or skills is related to the large search and matching literature in economics (for a review: Yashiv, 2007). This literature mostly focuses on studying the implications of frictions in the labour market on macroeconomic variables. Here we focus more on the implications the job matching has on the individual heterogeneity that survives in the job market and subsequently examine possible effects on the overall welfare of society.

Our simulation results first point to how personality variability can be adaptive depending on the job distribution in the system. We find that this adaptiveness is independent of initial distributions and that societal welfare stabilises after enough cycles are played out. We then study how switching the available jobs in the society can have implications to the society's welfare and also look at the implications of heterogeneous specialisation of agents. We finally consider the effect looser job recruitment screening can have on the composition of personality distributions and specialisation of agents as well as society's welfare.

2.2 Theory

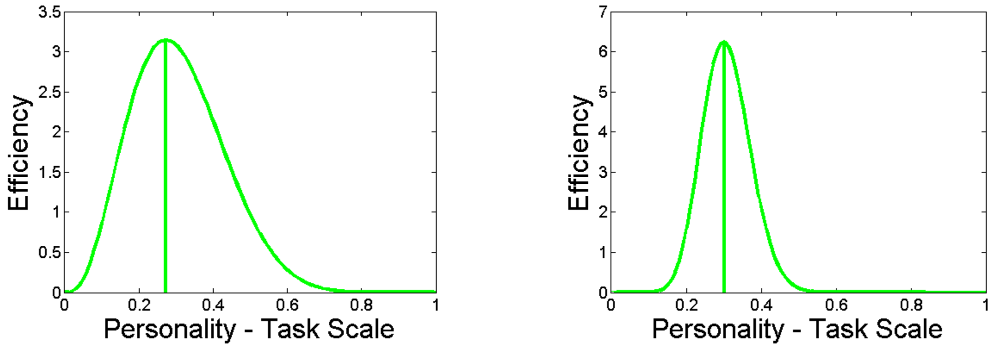
We consider a single measure of personality which is assumed to be measurable on a continuous scale between zero and one. One could think of this as simply one of the Big Five (e.g. Extraversion). Our first key assumption is that different levels of this personality measure translate to different optimal tasks - i.e. that people with a particular personality will be better at doing some jobs than others. In other words, we assume that personalities have a one-to-one relationship with the skills people possess in performing different tasks. As already mentioned this is similar to the modelling done by Almlund et al. (2011). They note that individual productivity can depend on different factors and they summarise this by: $P_j = \phi_j(\theta, e_j)$, where P_j is an individual's productivity for some task j, ϕ_j is the 'production' function for task j, e_j is the effort exerted to perform task j and finally θ is a vector of the aforementioned individual characteristics. This framework is rich, in that the vector θ can include a wide variety of individual characteristics (e.g. height, strength, education, problem-solving ability, etc.). The key aspect of this model that we borrow is that a person's personality can influence how efficient they are at performing different tasks.[1] Compared to Almlund et al. (2011), we relax the variation in effort exerted in each task [2] and also only allow agents to perform a single task at any given time period. This allows for the normalisation of their formula to $P = \phi(\theta, 1)$ and so allows us to specifically study the variation in traits across individuals.

Our second key assumption is that even though people have their optimal task (along the personality-task scale) they still can perform other tasks nearby this optimal one with some positive efficiency level depending on their individual personality distribution. We model individual personality distributions using a beta distribution. The two parameter specification of the distribution allows us to model specialisation on specific tasks. As the value of its two parameters increase in the same rate, the distribution becomes tighter. This induces a trade-off: individuals can achieve higher efficiency on their sweet-spot, while tasks further away from their sweet-spot become less efficiently performed.

As an illustrative example, consider figure 2.1. In the left panel of the figure

[1]Notice that if $\left(\frac{\partial^2 \phi_j}{\partial e_j \partial \theta'} > 0\right)$ then traits are complements to effort exerted and if $\left(\frac{\partial^2 \phi_j}{\partial e_j \partial \theta'} < 0\right)$ traits would then be substitutes to the effort exerted. This essentially helps to put forward our argument for how specific traits of personality can be better suited for some tasks, while not for others.

[2]That is, we normalise effort to be equal to 1.

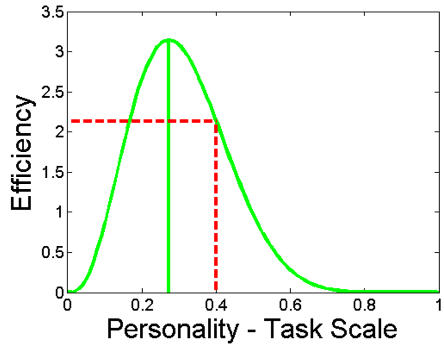


(a) Unspecialised (b) Specialised

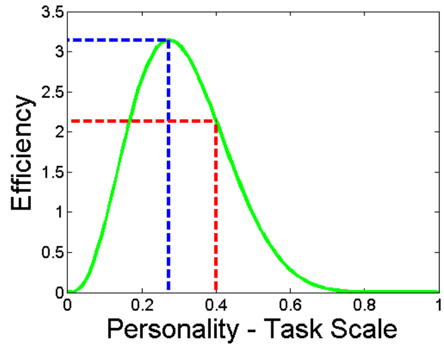
Figure 2.1: **Efficiency Distributions Examples**

we illustrate an individual's efficiency on different tasks along the personality-task scale. The peak of the distribution around 0.25 indicates that this particular agent would be best suited to perform the task at 0.25 with efficiency approximately 3 units. The right panel of figure 2.1 illustrates a different individual who again is best at performing the task at 0.25. In this case however, the individual is more specialised at performing this task hence allowing the agent to achieve more than 6 units of efficiency at her optimal task. There is however a downside to specialisation. By comparing the two distributions, it is obvious that performing tasks further away from their optimal tasks is more difficult for the agent in figure 2.1b. The agent in figure 2.1a would be able to perform tasks at around 0.6 with some non-zero efficiency, whereas the agent in 2.1b would be non-productive at task 0.6. The trade-off between higher efficiency and loss of diversified skills resulting from specialisation is the main reason why overspecialised agents will not be able to survive in our environment.

We measure two aspects of 'welfare'. First, we consider the efficiency with which a task is performed and, second, we consider dis-utility hypothesised to be suffered when an agent performs a task that is sub-optimal for them. Efficiency is defined in terms of the value of production an agent can produce while performing a task with a fixed amount of effort. We assume that all individuals are endowed



(a) Efficiency



(b) Mis-match dis-utility

Figure 2.2: **Welfare Components**

with an equal level of resources and we normalise this to be equal to one. From here onwards, whenever we talk about efficiency units, these are the units of production an agent can produce with an effort level equal to one. The agent in figure 2.1a, for example, can produce approximately 3 units of production if performing task located at 0.25. When we refer to 'welfare' we refer to this efficiency measure, as seen in figure 2.2a where we have indicated the efficiency level of the specific agent at performing the task located at 0.4. The second component to our analysis will be a measure of subjective well-being. The measure is calculated by comparing the efficiency achieved on the task being performed and an agent's optimal task. Figure 2.2b indicates the two levels we are referring to. The blue dotted line indicates the efficiency that can be achieved by this agent at their optimal task and the red dotted line indicates their efficiency at some task away from their optimal - in this case a task located at 0.4. This dis-utility is due to the fact that the agent is forced to perform a task that they are not necessarily good at which decreases their subjective well-being. To calculate this dis-utility component we take the ratio between the efficiency at which an agent is performing the job they have been chosen for and how efficient they would be had they been performing their optimal task. In the case of the agent in figure 2.2b, their subjective well-being according to our definition will be $\approx \frac{2}{3}$.

2.3 Simulation Model

We start with a random set of agents enjoying a randomly drawn personality distribution with a mode drawn from of a uniform distribution between zero and one. Consequently, random tasks are generated from either a uniform distribution or distributions that are skewed to the left or to the right. In order to create unemployment, we generate a number of tasks (j) that is smaller than the number of agents (n) in the society and hence the difference of the two absolute numbers gives us the rate of unemployment that will exist in each time cycle.

$$Unemployment = n - j \tag{2.1}$$

The number of agents and tasks is kept constant throughout all cycles of the simulation, hence making the unemployment rate constant throughout. One could think of this as the natural rate of unemployment. What varies is the rate of task separation, i.e. the number of agents losing their tasks within a time cycle. This will be explained further below.

Once the agents and the tasks have been generated, we allocate agents to tasks. The allocation process is intended to capture key features of the job-filling process in the real world. Each task is advertised consecutively and for each task the agent that is best for it is found, according to their efficiency at performing the said task. Specifically for each task j we perform the following maximisation:

$$\underset{(\alpha_i,\beta_i)}{\arg\max} \quad f(j, \alpha_i, \beta_i) \tag{2.2}$$

where j is the task for which the best agent is being searched for and α_i and β_i are the corresponding beta parameters from each available agent being considered. The function $f(.)$ corresponds to the probability density function of the beta

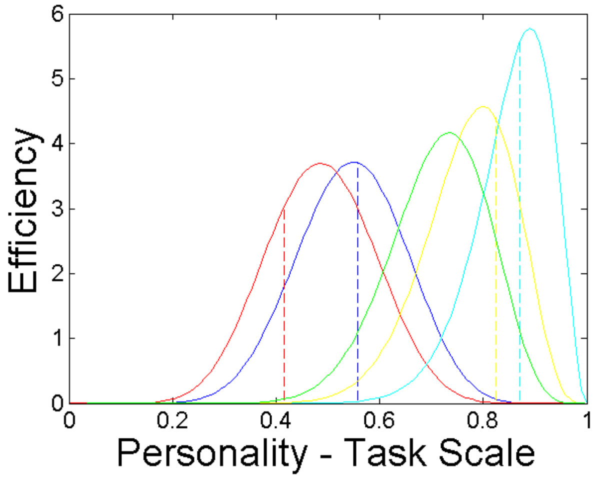


Figure 2.3: **Task Allocation Example**

distribution.[3]

Once the best agent for the task is found this task is considered filled and the agent taking up the task is removed from the available pool of agents for the next task to be filled. This process carries on until all available tasks are filled with the best available agent in each case. Figure 2.3 illustrates five random agents' personality distributions. The dotted lines indicate the tasks each of these agents have been allocated to. The agent with the green distribution is unemployed and for this reason has no task indicated in the figure. It is important to note that we do not allow for multiple agents to take up the same task.

Once all the available tasks get filled, as explained above, we calculate individual efficiency and subjective well-being values for each agent. The two measures are given by:

$$Eff(x_i, \alpha_i, \beta_i) = f(x_i, \alpha_i, \beta_i) \tag{2.3}$$

$$SWB_i = \frac{Eff(x_i, \alpha_i, \beta_i)}{Eff(x_i^*, \alpha_i, \beta_i)} \tag{2.4}$$

[3]Beta Distribution PDF: $f(x, \alpha, \beta) = \frac{x^{\alpha-1}(1-x)^{\beta-1}}{B(\alpha,\beta)}$

where x_i corresponds to the task each agent i is performing, x_i^* represents the optimal task for each agent i and the function $f(.)$ is the Beta Distribution PDF (see footnote 3).

Equation 2.4 depicts the calculation made to define the subjective well-being of each agent following from the explanation in the previous section. The closer the job performed is to the peak of their distribution, the greater is their subjective well-being. The range of values for this measure varies between 0 and 1.

The unemployed agents are assumed to be unproductive and hence receive Eff_i equal to zero. All unemployed agents are subsequently replaced by new random agents who will be competing in the next task allocation cycle. Unless stated otherwise, the replacement agents are drawn from the uniform distribution.

The number of tasks lost within each cycle varies. The intuition behind this is as follows. Consider an economy which goes through various business cycles. During booms the number of jobs lost are significantly lower than during recessionary periods. The varying number of tasks lost across different cycles is considered to be a rough approximation of this phenomenon. The probability of each agent losing their task is dependent on their efficiency. The higher efficiency an agent enjoys, the lower is the probability of her losing her allocated task. This allows for well-performing personalities to survive in the population. At the same time this specification allows for some random chance of agents losing their task even if they are good at it. More precisely, once the welfare levels of all agents are computed, they are normalised to be in the range $(0, 1)$ using:

$$Eff_i^{norm} = \frac{Eff_i - Eff^{min}}{Eff^{max}} \tag{2.5}$$

This normalised welfare level of each agent, Eff_i^{norm}, is then weighted according to each individual's subjective well-being and the resulting number is the probability that they will enter an *insecure* state in their task. Specifically, this probability is given by:

$$q_i = SWB_i * Eff_i^{norm} \tag{2.6}$$

This weighting of individual efficiencies to determine q_i is included to account for the fact that if individuals do not feel like they are a good fit to their job this might cause them distress. Given the recent evidence by Oswald, Proto and Sgroi (2015) we believed that it was a fair assumption to make that lower subjective well-being could be detrimental to individual productivity and efficiency at a task - leading to lower likelihood of retaining your job.

Once in the insecure state, agents are offered a further chance to retain their jobs as they will lose their task with probability 10%. This extra chance was included in the simulation model to mirror real life situations where individuals will be warned that their position is in danger but are given a chance to validate themselves, akin to how football managers are given 'ultimatums' when their teams are performing below par.

Once the tasks that have become available after task separation are determined, then the task separated and newly introduced agents in the system compete for these. The way allocation works is exactly as explained above, where for each available task the best available agent is selected and so on. We do not allow for agents that lose a task to get re-allocated to it within the same cycle. If this is allowed then we end up having agents losing and being re-allocated to the same task in the same cycle, which did not seem to be a plausible reflection of real life.

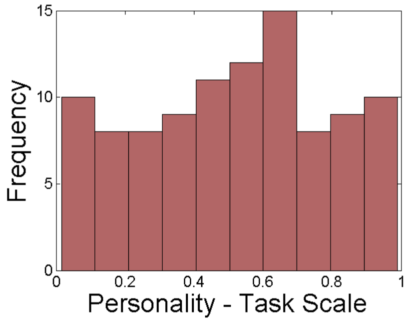
2.4 Results & Discussion

In this section we start analysing and discussing the results that we get from our agent based simulation. Each subsection below is meant to highlight the key findings, and within each subsection we elaborate further on the implications of these findings.

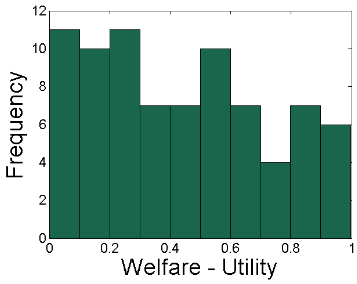
2.4.1 Personality Distribution Matches Task Distribution

An initial result is that, once the agents are allowed to play the game, the personality distribution of the population starts mimicking the task distribution. That is, the demand of particular types is eventually supplied. In intuitive terms, this happens because the agents with traits that cannot be catered for from the tasks available are not able to be productive and are eventually removed from the population. In figure 2.4a we have plotted the initial personality distribution in the population that took part in the simulation we are reporting in this subsection. This histogram indicates the personality distribution in the population, given each agent's mode from their own respective personality distributions. By examining figure 2.4 the reader can easily identify this tendency already mentioned. In all three different types of task distributions considered[4], the personality distribution of the agent population appears to be converging towards the task distribution. This is further confirmed if one checks table 2.1 where we list the p-value outcomes from a Kolmogorov-Smirnov test in comparing the various personality distributions and task distributions in the different cases. We fail to reject the null for the uniform case that the two distributions are different both at the initial stage and at the end stage. This of course is not surprising as the initial values in both distributions (agents' optimal tasks and task distribution) are values taken randomly from the uniform distribution in the range $(0, 1)$. In the other two cases, where the distribution is skewed either to the left or the right, the initial personality distributions are found to be significantly different at the initial stage. After running the simulation, we are not able to reject the null and thus conclude that eventual personality distributions closely match the task distribution.

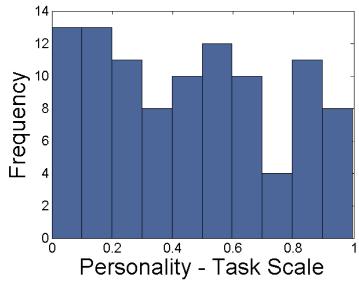
[4]To create the task distribution with left skew, we drew random numbers from a Beta distribution with $\alpha = 8$ and $\beta = 2$. For the task distribution with right skew, we drew random numbers from a Beta distribution with $\alpha = 2$ and $\beta = 8$. In all cases where we vary a distribution's skewness we use the same parameters.



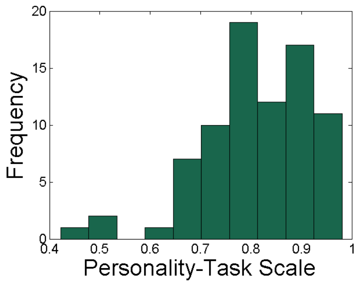
(a) Initial Personality Distribution (Drawn from Uniform Distribution)



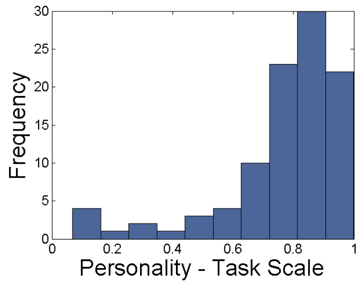
(b) Uniform Task Distribution



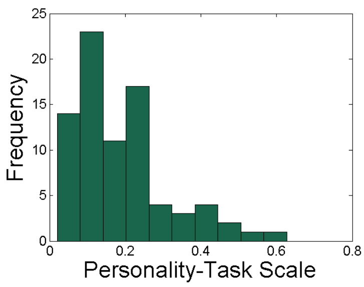
(c) Uniform Final Personality Distribution



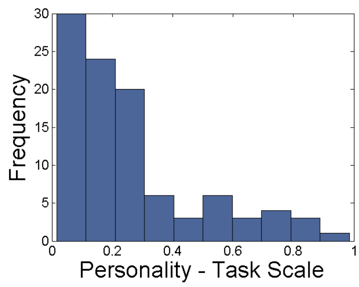
(d) Task Distribution with Left Skew



(e) Skewed Left Final Personality Distribution



(f) Task Distribution with Risk Skew



(g) Skewed Right Final Personality Distribution

Figure 2.4: **Personality Distribution Simulation Results** (after 10,000 cycles)

Task Distribution Type	Initial Personality Distribution	Final Personality Distribution
Uniform	0.0996	0.9843
Skewed Right	0.000	0.2663
Skewed Left	0.000	0.1869

Table 2.1: **Kolmogorov-Smirnov Test p-values**

2.4.2 Welfare Analysis for Individual Agents and Whole Society

In this subsection we examine societal welfare and how it evolves through the cycles of the simulation. To calculate societal welfare we simply sum up the welfare recorded for each agent in the society. In figure 2.5 we present the averaged welfare over 10 repetitions of the simulation described above. The left column presents the evolution in the first 100 cycles, the middle column shows the evolution across 1,000 cycles and finally the rightmost column presents the society efficiency evolution throughout all of the 10,000 cycles of the simulation.

Across all task distributions societal welfare increases very early in the simulation and reaches some stable level from as early as 100 cycles. This indicates how the evolution of the personality distribution in reaction to the task distribution is quite rapid. An additional question is whether the welfare distribution is unequal in the society. To investigate this, we graph in figures 2.6 and 2.7 the welfare distribution of the society at various time periods across the simulation for the case of task distributions with a left skew and a right skew respectively.

In both cases the welfare distribution starts with the mode being on zero utility, which reflects the mismatch between the personality distribution supplied in the system and the distribution of tasks available. As the simulation runs, the welfare distribution slowly moves to more positive values ending up with a mode around 5 in both the left and right skew simulations. The distributions during their transition have a skew to the right, indicating that some agents start getting better off early on but eventually in the end of the simulation the welfare distribution appears to be symmetrical.[5]

In figures 2.8 and 2.9 we graph the subjective well-being distribution of the society in various time periods across the simulation for the task distributions with a left skew and a right skew respectively. Similar to the welfare distribution discussed above, the subjective well-being distribution starts with a mode at 0 and slowly evolves to have a mode at 1 by the end of the simulation. The evolution of the distribution here indicates how the agents surviving in the society are essentially what the society requires (given the tasks distribution) and that is why most agents are able to enjoy the maximal possible subjective well-being. In other words, the people that survive are able to match quite well to jobs and hence do not suffer any great levels of dis-satisfaction due to mis-matching.[6]

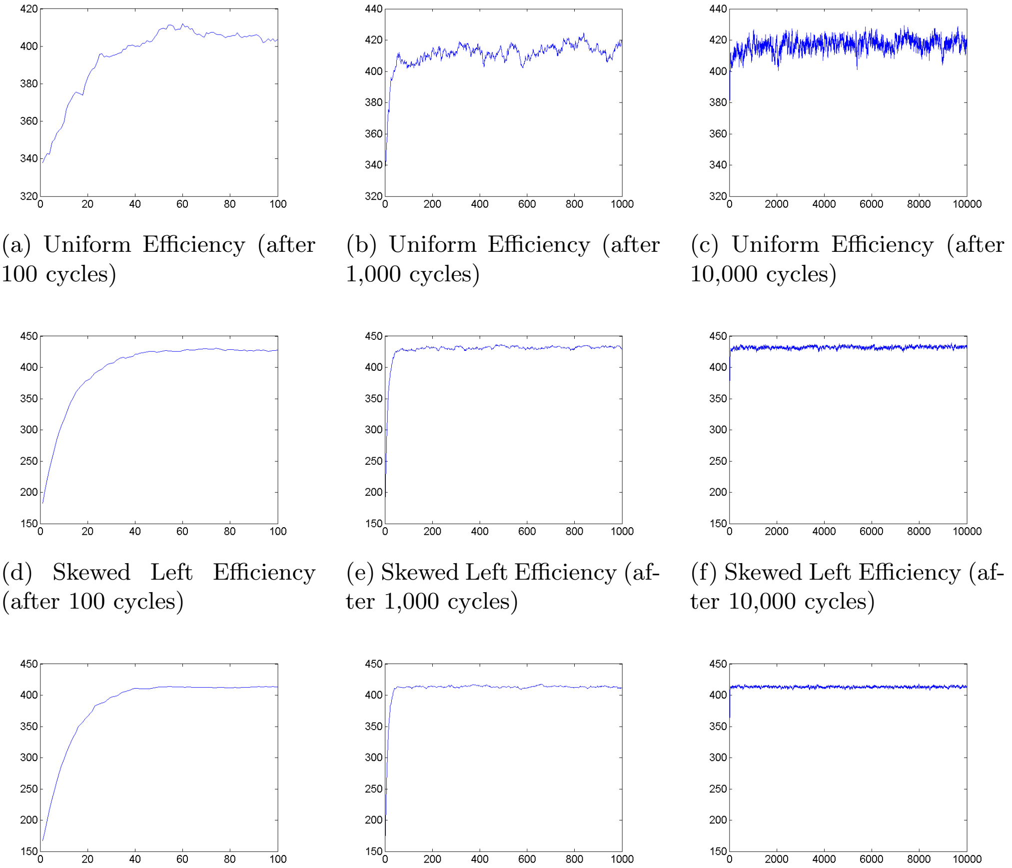
2.4.3 Robustness checks

Varying Initial Personality Distribution

To test the robustness of the distribution matching result we have just reported, we ran the simulation with different initial personality distributions. In one case we started with an initial personality distribution that was skewed to the right while the task distribution was skewed to the left and in a second case we ran the simulation with the converse case. Specifically, we compared a skewed to the left initial personality distribution against a task distribution with a right skew and vice versa. The results of these two simulations are presented in figure 2.10. As it is clear from the figures, it does not matter with what initial personality distribution we perform the simulation as in both cases the final personality distribution ends up matching the task distribution. This conclusion is further confirmed by the test results presented in table 2.2 where we ran Kolmogorov-Smirnov tests between the personality and task distributions in the initial and final stages. In both cases the

[5] The 20 agents with 0 efficiency evident in the figure from 100 cycles onwards are the unemployed who are consider to be unproductive and hence inefficient.

[6] See footnote 5 for why there are 20 agents with 0.



(a) Uniform Efficiency (after 100 cycles)

(b) Uniform Efficiency (after 1,000 cycles)

(c) Uniform Efficiency (after 10,000 cycles)

(d) Skewed Left Efficiency (after 100 cycles)

(e) Skewed Left Efficiency (after 1,000 cycles)

(f) Skewed Left Efficiency (after 10,000 cycles)

(g) Skewed Right Efficiency (after 100 cycles)

(h) Skewed Right Efficiency (after 1,000 cycles)

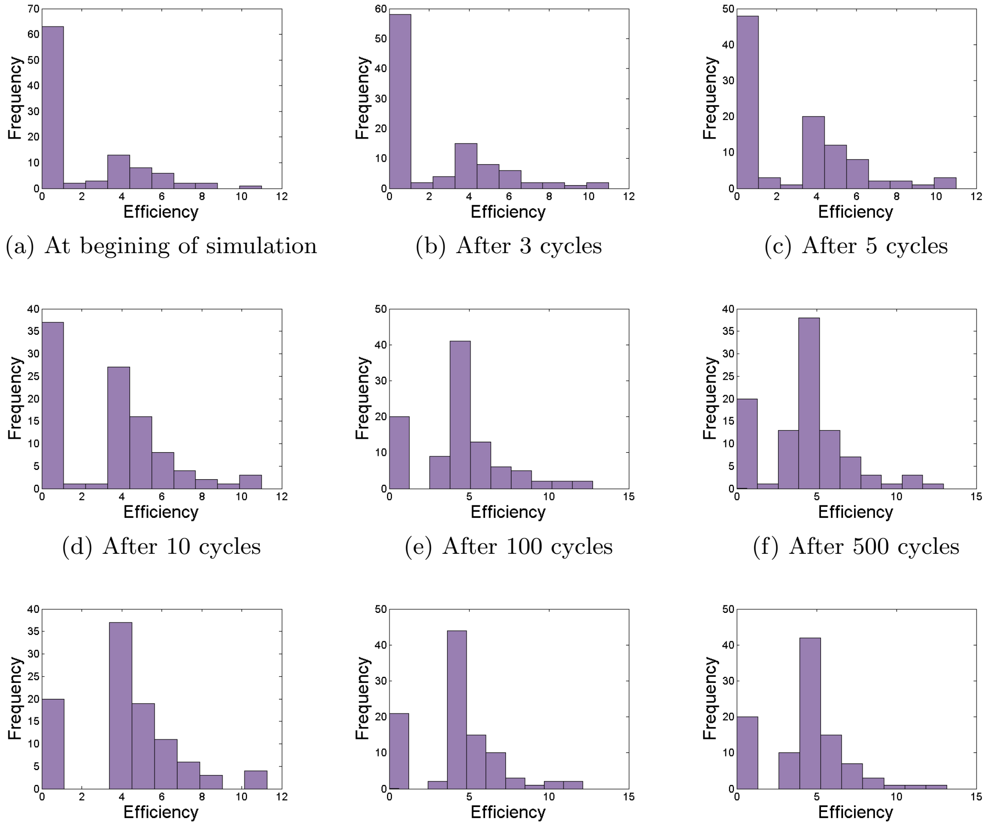
(i) Skewed Right Efficiency (after 10,000 cycles)

Figure 2.5: **Society total efficiency across cycles** (averaged over 10 repetitions)

null is rejected at the initial stage but not rejected once the simulation is run.

Iniital Distribution Type	Initial Personality Distribution	Final Personality Distribution
Skewed Left	0.000	0.3042
Skewed Right	0.000	0.2663

Table 2.2: **Kolmogorov-Smirnov Test p-values** - Varying Initial Personality Distributions



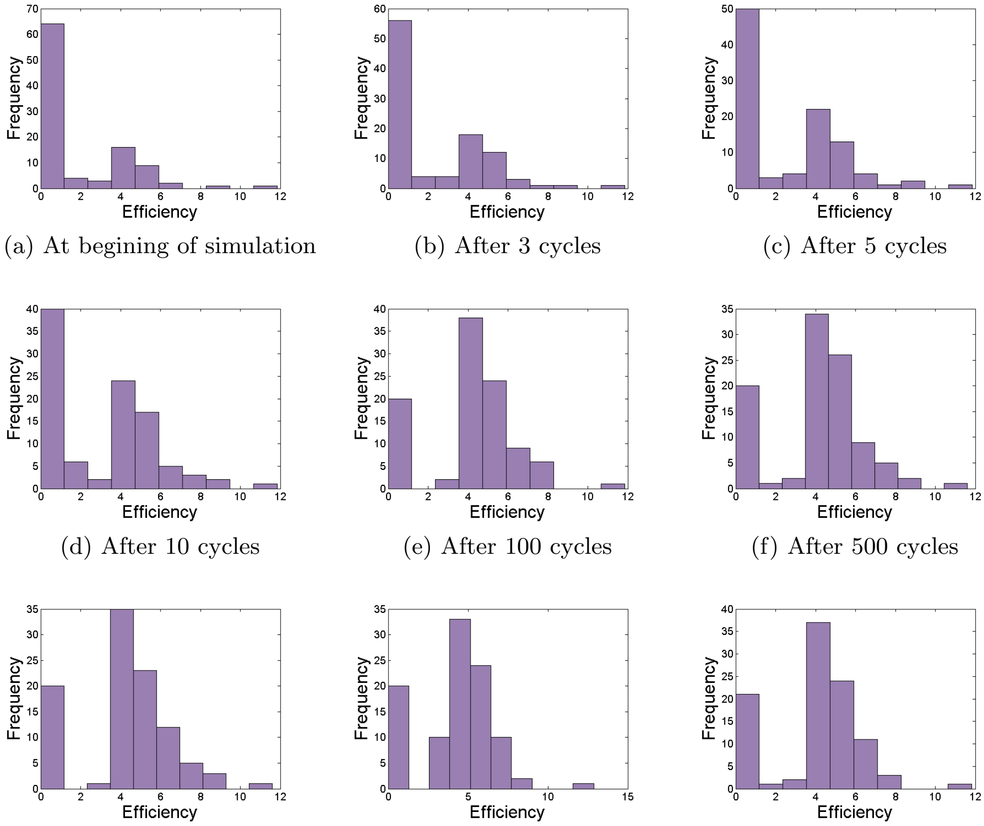
(a) At begining of simulation
(b) After 3 cycles
(c) After 5 cycles
(d) After 10 cycles
(e) After 100 cycles
(f) After 500 cycles
(g) After 1,000 cycles
(h) After 5,000 cycles
(i) After 10,000 cycles

Figure 2.6: **Society Efficiency Distribution Across Cycles** - Tasks with Left Skew

Replacing from 'wrong' pool of agents

An interesting investigation of how robust these results are is the case where the agents introduced in the system to replace the unemployed ones are drawn from the 'wrong' distribution. That is, in the case where the task distribution has left skew, rather than replacing agents drawn from the uniform distribution we replaced agents drawn from a distribution of personalities with a right skew. This could be seen as reflecting a case in real-life where the skills of workers coming in the labour market would be obsolete. That is, the skills offered from the newcomers entering the market are not the ones required.

The results of this simulation are presented in figure 2.11. In panel 2.11c it



(a) At begining of simulation (b) After 3 cycles (c) After 5 cycles

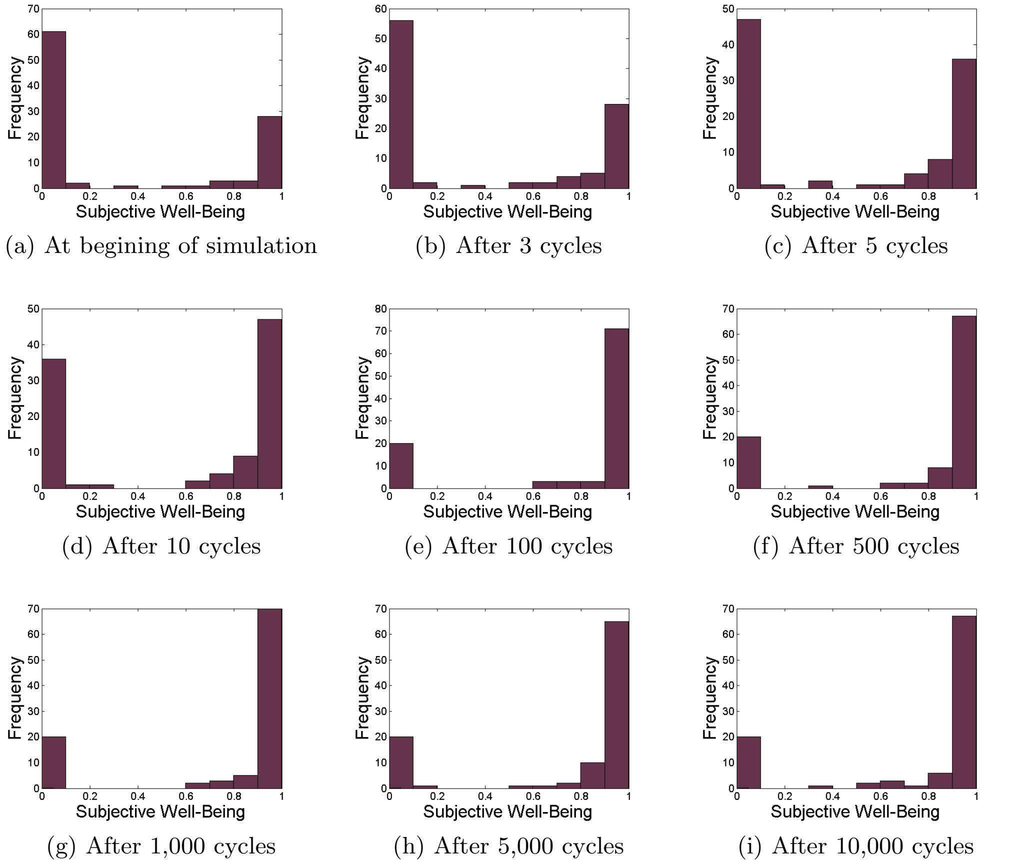
(d) After 10 cycles (e) After 100 cycles (f) After 500 cycles

(g) After 1,000 cycles (h) After 5,000 cycles (i) After 10,000 cycles

Figure 2.7: **Society Efficiency Distribution Across Cycles** - Tasks with Right Skew

can be seen that the personality distribution even after 10,000 cycles has not yet fully matched the task distribution. Running a Kolmogorov-Smirnov test fails to reject the null that the two distributions are different with a p-value of 0.000. In the second row of figure 2.11 we graph the evolution of societal welfare over the simulation. The societal welfare tends to grow in the initial stages and in fact after 1,000 cycles (panel e) seems to reach a peak. In panel f, however, one can see how welfare eventually follows a downward trend and then appears to stabilise at a level below the initial society welfare enjoyed in the early stages of the simulation.

These results seem to indicate that education needs to adapt to the needs of the economy as these change, otherwise welfare in society deteriorates. This



(a) At begining of simulation (b) After 3 cycles (c) After 5 cycles

(d) After 10 cycles (e) After 100 cycles (f) After 500 cycles

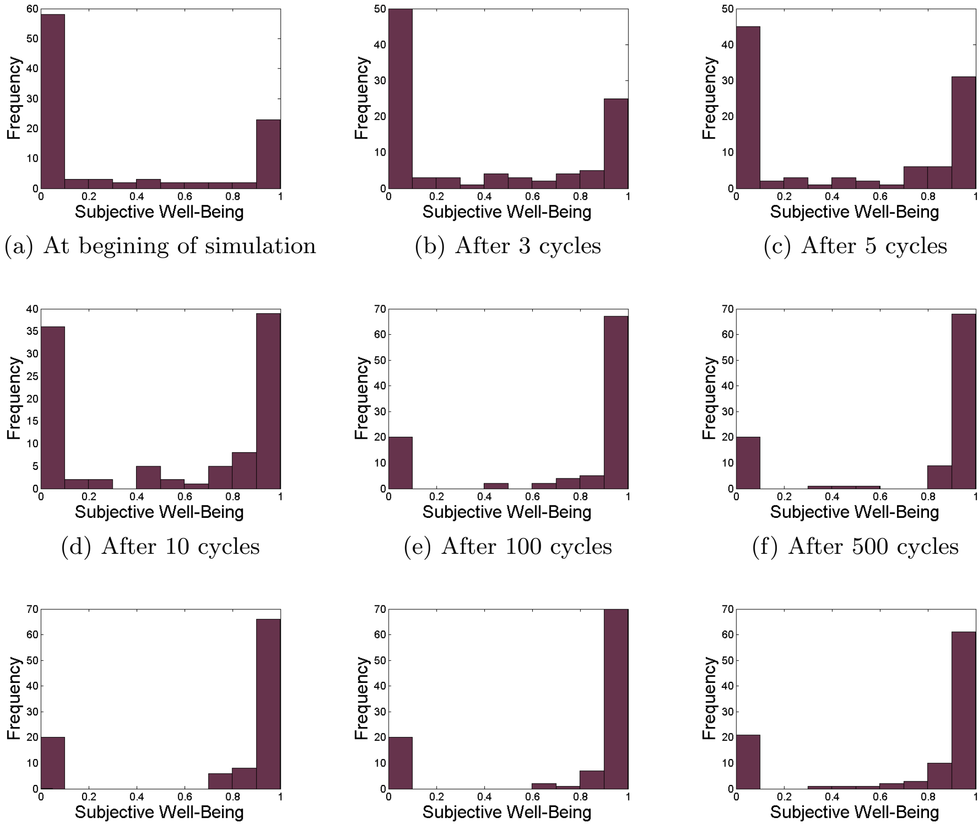
(g) After 1,000 cycles (h) After 5,000 cycles (i) After 10,000 cycles

Figure 2.8: **Society SWB Distribution Across Cycles** - Tasks with Left Skew

is because the workers available in the market are not necessarily relevant to the jobs offered and so are not able to achieve high levels of efficiency. That is, we need to recognize the possibility that some individuals' traits might not be catered for in the jobs available. Hence, education or training opportunities need to be appropriated to assist in helping such individuals to effectively perform within the available jobs/tasks.

2.4.4 Technological Change

An important factor to consider would be the possibility of technological change. We assume that technological change will change the task distribution that is demanded in the system. For example, in pre-historic times a lot more hunters and



(a) At begining of simulation (b) After 3 cycles (c) After 5 cycles

(d) After 10 cycles (e) After 100 cycles (f) After 500 cycles

(g) After 1,000 cycles (h) After 5,000 cycles (i) After 10,000 cycles

Figure 2.9: **Society SWB Distribution Across Cycles** - Tasks with Right Skew

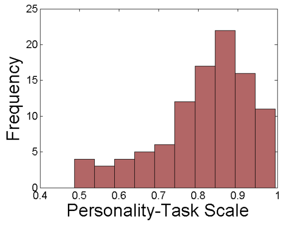
gatherers were needed whereas now a lot more programmers and investment bankers are demanded in the different economies of the world.

We envision that such changes can happen in two ways:

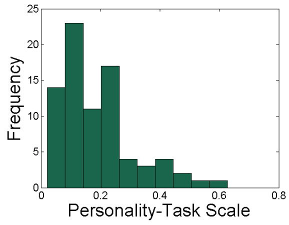
- Sudden and abrupt change in the task distribution (perhaps following a catastrophe)

- One task at a time changing as jobs start becoming obsolete

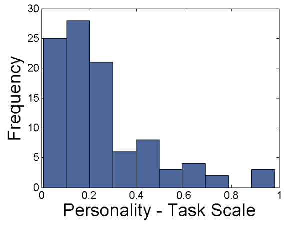
Given these two possibilities, we ran simulations to test how our previous results would compare as well as investigate how welfare of the society would be affected given such changes.



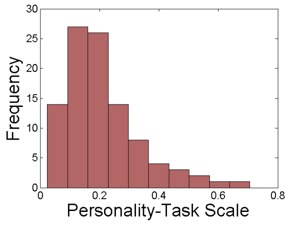
(a) Initial Personality Distribution with Left Skew



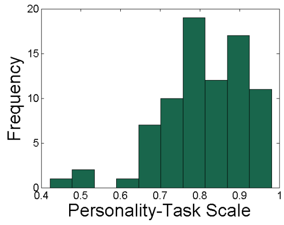
(b) Task Distribution with Right Skew



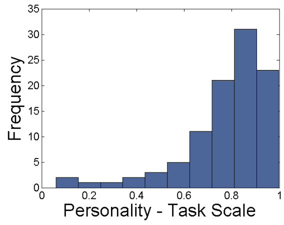
(c) Final Personality Distribution



(d) Initial Personality Distribution with Right Skew



(e) Task Distribution with Left Skew



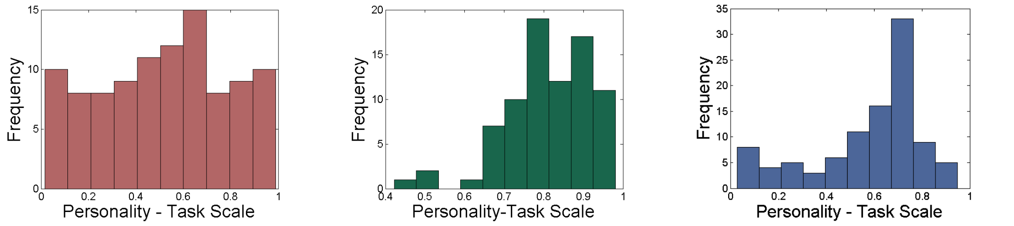
(f) Final Personality Distribution

Figure 2.10: **Varying Initial Personality Distribution Simulation Results** (after 1,000 cycles)

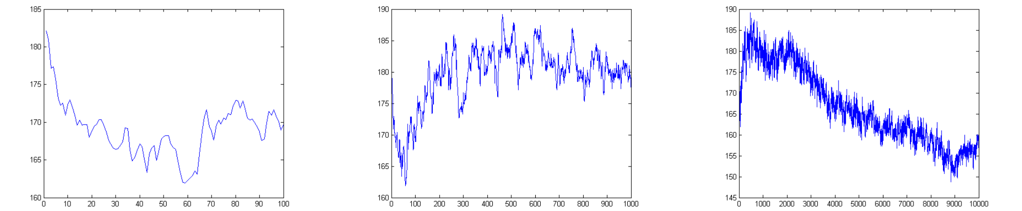
Sudden & Abrupt Change

In this possible scenario, the reader should think of it along the lines of a sudden structural change in the economy our system is modelling. Possibly following a catastrophe, the whole landscape of tasks available has changed. To model this we ran a simulation where halfway through the cycles the task distribution is switched from one with a right skew to one with a left skew.

As seen in figure 2.12, despite the change in the task distribution the personality distribution is still able to mimic the eventual task distribution by the end of the simulation. This is further confirmed after running the Komogorov-Smirnov test where we fail to reject the null ($p = 0.7977$). It is interesting to note how quick the response is to the change from the agents' side. In panels (e) and (f) of figure 2.12, where we graph the societal welfare evolution through the simulation, we can see how the welfare is affected by the sudden switch. In panel (e) of figure 2.12 we note a dip in the society welfare at the moment of the switch. By further investigating



(a) Initial Personality Distribution (b) Task Distribution (c) Final Personality Distribution



(d) Society Welfare after 100 cycles (e) Society Welfare after 1,000 cycles (f) Society Welfare after 10,000 cycles

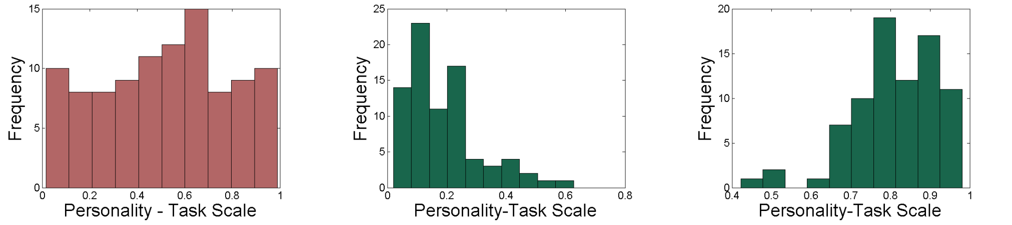
Figure 2.11: **Replacing from 'wrong' pool of agents simulation results** (after 10,000 cycles)

Note: Averaged over 10 repetitions for the welfare graphs

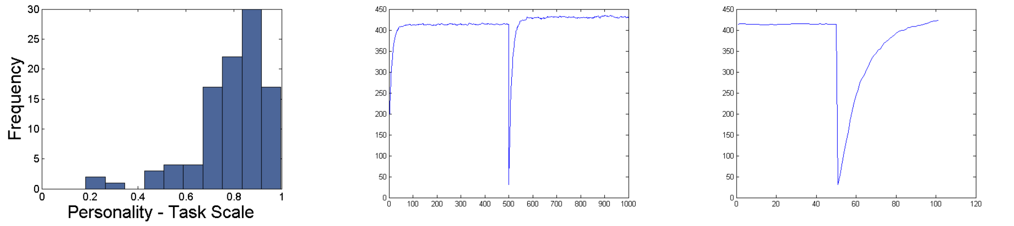
the evolution of welfare closer to the point of impact (panel (f)) we can see that within 30 time periods the society welfare recovers back to the levels prior to the switch in the task distribution.

Tasks switching one at a time

Under this scenario of technological change, once the society welfare stabilises at the steady state level, we slowly introduce changes in the task distribution available. Specifically, between cycles 150 and 230 of the simulation, one random task at a time was chosen and replaced from tasks drawn from an oppositely skewed beta distribution. To make this clearer, in figure 2.13b we depict the original task distribution that has a right skew. In figure 2.13c, the eventual task distribution is presented after the transformation has taken place. To some extent we have the same change in the task distribution as in the subsection above, only in this case the change is gradual rather than sudden. This type of technological change could



(a) Initial Uniform Personality Distribution (b) Initial Task Distribution with Right Skew (c) Eventual Task Distribution with Left Skew

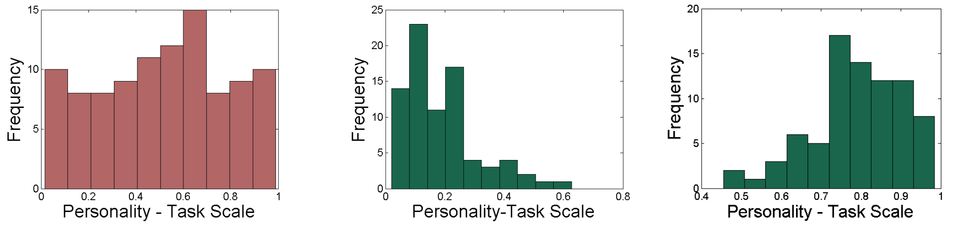


(d) Final Personality Distribution (e) Society Welfare after 1,000 cycles (f) Society Welfare at impact

Figure 2.12: **Sudden Switch in Task Distribution Simulation Results** (after 1,000 cycles)

be seen to be a closer example of jobs slowly becoming obsolete and gradually being replaced by new jobs.

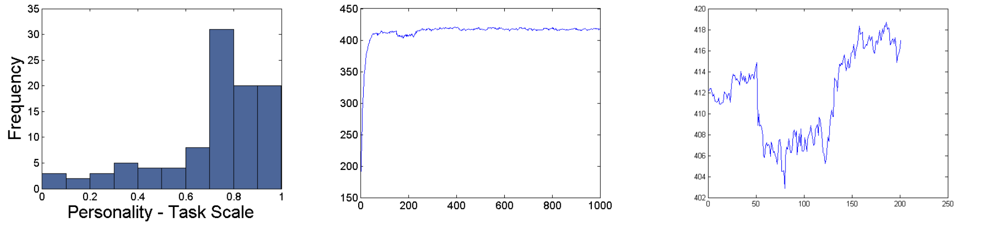
It is clear from figure 2.13d that the personality distribution is again able to mimic the task distribution by the end of the simulation. The interesting point illustrated by this simulation is how little the welfare of society is affected by the gradual change in the task distribtution. In panel 2.13e where we graph the evolution of the society welfare, it is quite clear that the change in the task distribution has a negligible effect on the welfare evolution. When looked more closely in figure 2.13f, we can see that the society welfare only drops at the lowest by about 12 units and then returns back to its long run values very quickly within 50 time periods. This we believe shows how adaptive the agents are and how quickly they incorporate the gradual technological change taking place.



(a) Initial Uniform Personality Distribution

(b) Initial Task Distribution with Right Skew

(c) Eventual Task Distribution with Left Skew



(d) Final Personality Distribution

(e) Society Welfare after 1,000 cycles

(f) Society Welfare at impact

Figure 2.13: **One at a Time Switch in Task Distribution Simulation Results** (after 1,000 cycles)

2.4.5 Varying Specialisation

So far, in all the analyses presented we have kept the specialisation of individual agents constant. More specifically when generating our random agents' beta parameters that characterise their personality distributions, the sum of these has been restricted to equal to 20. That is, $\alpha_i + \beta_i = 20, \forall i$.

Given that the variance of a beta distribution is given by:

$$var(X) = \frac{\alpha\beta}{(\alpha+\beta)^2(\alpha+\beta+1)}$$

Varying the sum of the two beta parameters is equivalent to varying the precision[7], or in our context, specialisation of our agents. In this section we will do exactly this; we will first study the effect on society's welfare and subjective well-being as agents are more specialised as a whole and secondly study the implications

[7]Conventionally, precision is defined as the reciprocal of the variance, $\frac{1}{var(X)}$

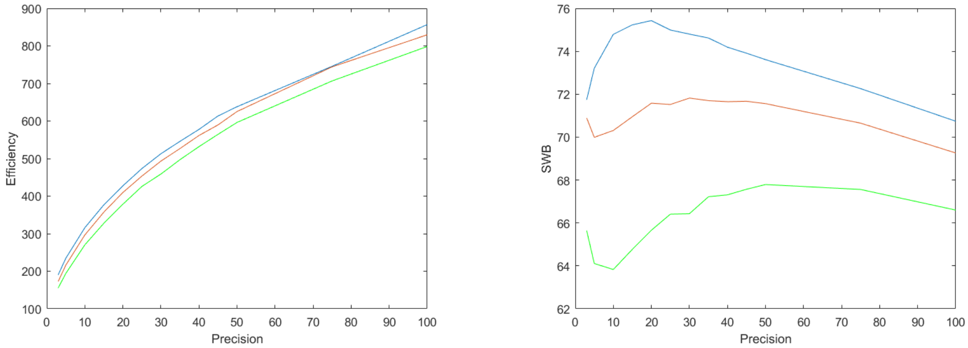
of having different levels of specialisation within the same population. For the latter we split the agent population in two, low and highly specialised and investigate how the proportions of these two sub-populations evolve through the simulation.

Additionally, in this section we introduce some imperfect monitoring of agents' efficiency in various tasks. Across all the simulations so far, when a task was to be filled, there was perfect information on each agent's efficiency for the given task. That is, there was perfect screening during task matching. Here we introduce some noise into the task matching process so that it does not allow for perfect screening. Specifically, when the efficiency of an agent is determined for a specific task, a random number drawn from the normal distribution with a standard deviation of 1 or 2 is added to 'cloud' the true efficiency value.

Varying Population Specialisation

Figure 2.14 graphs the way society efficiency and subjective well-being vary as the population becomes more specialised as a whole. The blue lines represent the case where there is perfect screening during the task matching stage. Red lines when there is a 1 standard deviation of noise added during the screening process and green lines when there is 2 standard deviations of noise added during the screening stage. The population precision is varied between 10 and 100 (i.e. the sum of the beta parameters is varied between 10 and 100). What we graph at each precision is the average level of both efficiency and subjective well-being from the point at which the trend stabilises (as seen in the previous efficiency trend figures i.e. figure 2.5)

First focusing our attention on the left panel, we can see that as the population becomes more and more specialised society's productivity increases as well. This of course, is to be expected. With an increasingly specialised population a more optimal division of labour can be achieved and a resulting higher welfare output is enjoyed by the population. Introducing noise does not result in major issues for



(a) Efficiency (b) SWB

Figure 2.14: **Approximate Stable Welfare Values** (after 1,000 cycles)
Note: Blue: No Noise, Red: 1sd Noise, Green: 2sd Noise

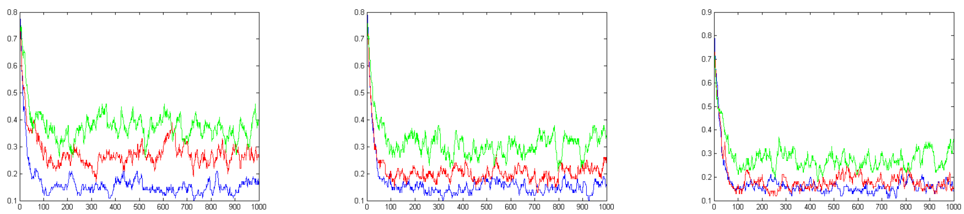
efficiency; there is a downward shift of the line but it is not a very dramatic change.

An insight we gain from this exercise can be seen in the right panel of figure 2.14. First focusing on the case of no noise (blue line) one can notice how as the population becomes more specialised, the society's SWB is dropping. This is due to the fact that as agents are more specialised it becomes harder and harder to accommodate their very specific task needs at which they are specialised. When noise is introduced, this problem is not as pronounced and in fact the trend almost flattens when adding 2 standard deviations of noise (green line). The green line in the figure shows that when the screening is not stringent enough to identify the exact attributes of the agents, the overall SWB drops in the society as agents cannot be matched close to their optimal task.

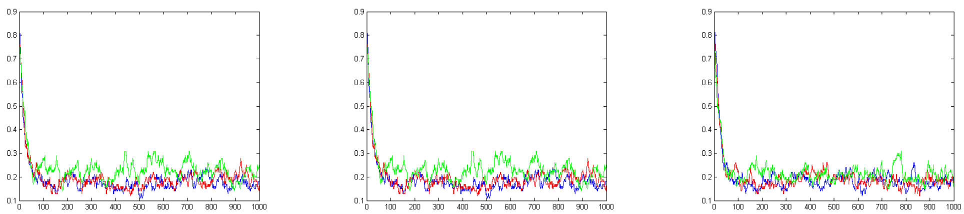
Discrete Heterogeneity in Specialisation

As described above, we investigate how the proportions of low and highly specialised agents evolve through the cycles of the simulation. We arbitrarily split the agent population into two and specify specialisation values for the two sub-populations and allow them to interact in the simulation. When new agents are introduced in the system they are equally likely to be highly or low specialised.

As we wanted to investigate whether unspecialised individuals would eventually survive the simulation, we specify the low specialisation of our agents to be equal to 10; which is lower than the value we have been using throughout the analysis so far. What we vary is the level of specialisation of the highly specialised group, starting from 20 going up to 100. Figure 2.15 presents the results of these simulations. Across all simulations we start with 80% of the population being of the low precision type. Focusing first on the blue line (no noise case), it is clear across the different panels in figure 2.15 that this proportion is very high and not sustainable as the proportion of low precision individuals quickly drops as early as within 50 cycles. The proportion appears to stabilise after around 100 cycles and thereafter and across all simulations it seems to be just below 20% of the population. This remains stable around this range even if the simulation is run further up to 10,000 cycles. This general result of low precision (low specialised) agents robustly surviving in the population is quite striking when one considers that population effciency has an increasing relationship with agent precision. This leads to the conclusion that irrepsective of the benefits of specialising, some unskilled or unspecialised agents are always needed in the population.



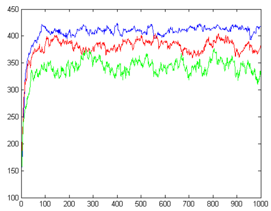
(a) High Specialisation = 20 (b) High Specialisation = 30 (c) High Specialisation = 40



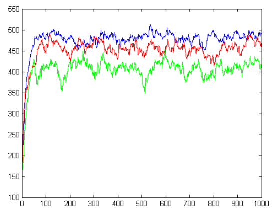
(d) High Specialisation = 50 (e) High Specialisation = 75 (f) High Specialisation = 100

Figure 2.15: **Evolution of low precision population share** (after 1,000 cycles)
Note: Blue: No Noise, Red: 1sd Noise, Green: 2sd Noise

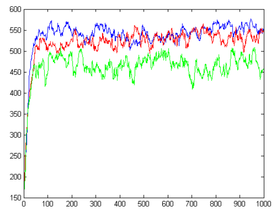
If we now consider the red and green lines in figure 2.15 it becomes clear that as the screening process becomes more noisy, more unspecialized agents are able to survive in the system - in the top panel of the figure. This happens because due to the poor screening process, unspecialized agents are surviving under the radar as the hiring process is not able to detect them. This effect of the noise slowly erodes as we consider higher specialisation values for the specialised group (moving along the figure from 2.15a to 2.15f). In fact, by the bottom right panel of figure 2.15 there is very negligible difference across the different noise scenaria simulations. This is due to the fact that since the specialised group is very specialised, even with the sub-optimal screening process, they are able to signal their advantage by the much higher efficiency values they can achieve.



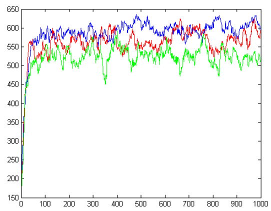
(a) High Specialisation = 20



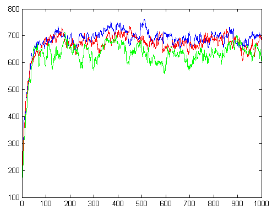
(b) High Specialisation = 30



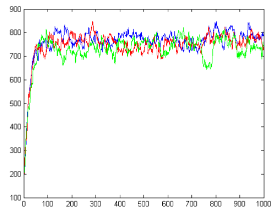
(c) High Specialisation = 40



(d) High Specialisation = 50



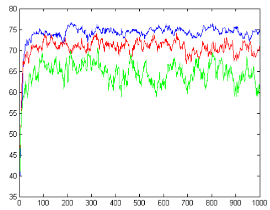
(e) High Specialisation = 75



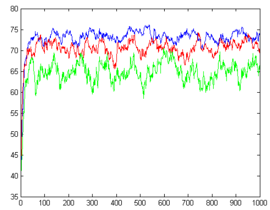
(f) High Specialisation = 100

Figure 2.16: **Evolution of Efficiency** (after 1,000 cycles)
Note: Blue: No Noise, Red: 1sd Noise, Green: 2sd Noise

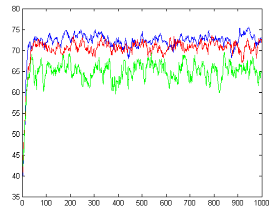
In figures 2.16 and 2.17 we graph the evolution of the society's welfare/efficiency and SWB respectively. Similarly to figure 2.15 as we move along panels of both figures, the noisy cases are not readily distinguishable from the no-noise case. As expected, given the analysis in the previous subsection, the more noise is added to the system, the lower is the resulting trend for both efficiency and SWB.



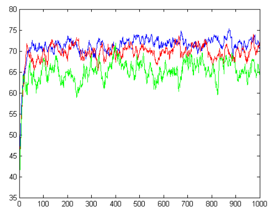
(a) High Specialisation = 20



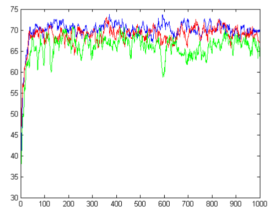
(b) High Specialisation = 30



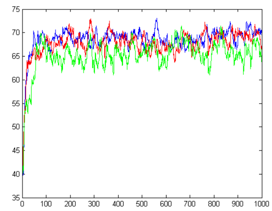
(c) High Specialisation = 40



(d) High Specialisation = 50



(e) High Specialisation = 75



(f) High Specialisation = 100

Figure 2.17: **Evolution of SWB** (after 1,000 cycles)
Note: Blue: No Noise, Red: 1sd Noise, Green: 2sd Noise

2.5 Conclusions

In this paper we set out to answer some questions about individual differences in humans, the effects different compositions of personality types can have on society's welfare, and the effect more or less stringent hiring processes can have on a society's personality composition and welfare. To do this we combined approaches to the study of personality from economic and evolutionary psychology and set up an agent based model simulation that allows us to provide some insights on these questions.

We find that the personality composition of the population is very adaptive. Irrespective of the initial personality composition, across our simulations, we have found that agents surviving in the system are what the society requires through the tasks that are available. That is, the personality types in the population evolve to cater for the demand existing. This happens because the types that are not useful - given the tasks available in the system - are not able to offer any productive output and eventually disappear from the population. Both the society's efficiency and subjective well-being are stabilized by the end of the simulations.

We also study what would happen if the education system was offering obsolete skills to the incoming working population. In this simulation we find that the personality composition is not able to exactly mirror the task distribution due to the constant push from the 'wrong' skills that are being taught to the agents coming into the society. The effects we find for societal welfare are large. The efficiency levels never reach the level found in the previous simulations and in fact stabilize at levels less than half of these. These are quite strong predictions and they appear to suggest that education needs to adapt to the needs of society. By doing so, individuals that are not adequately fit for the jobs that are available in an economy can potentially be assisted in achieving some productive output despite their niche or outlying personality type.

We then go on to study the effects of switching the tasks or jobs available in the society. These simulations again show how adaptive the personality composition of the population can be, in that the switching is accommodated very quickly. We perform this task switching in two ways; firstly with a sudden switch and secondly with a slow, gradual change. With the sudden switch we find a rapid reversion back to previous welfare levels and with the gradual change we find very small effects on welfare.

Finally, we study the effect training or specializing on different jobs on welfare and personality compositions of the population. We first vary the specialization of the population as a whole and analyze the effect this has on efficiency and subjective well-being after the population has stabilized. We find that societal efficiency grows with the increasing specialization of the agents but that subjective well-being is decreasing. That efficiency is always increasing with the precision or specialization of agents should not be surprising. The higher efficiency that agents can produce allows for a better division of labour that achieves a more efficient outcome for the society. The important insight of decreasing subjective well-being as agents become more specialized should not be taken lightly. It perhaps can help to shed some light on the reasons for the Easterlin Paradox. Briefly, the Easterlin Paradox talks about how even though countries are becoming richer in terms of GDP, the happiness scores are remaining stable - in some cases even falling. Countries are becoming richer due to many reasons, including the better technology available. The advances in technology and education allow workers to become more specialized and hence more productive. The problem is that, as our simulation results show, increased specialisation results in a negative effect on subjective well-being.

Within the analysis of the population's specialisation, we also study the possibility of having heterogeneous specialisation within the population. More precisely, we have two groups: low specialisation and high specialisation agents. The simulation results indicate how there will always be a surviving proportion of unspecialised agents in the population. This to some extent confirms the conventional wisdom of the need for a jack of all trades. When introducing noise in the job matching process, the surviving proportion of unspecialised agents becomes larger. This firstly can provide some insight into why there exist varying levels of trained individuals in today's society. Since job screening cannot be done in a perfect monitoring environment (no noise case), the unspecialised individuals are able to survive through. Secondly, given that with more noise in the selection process the society ends up with lower efficiency *and* lower subjective well-being these results serve as an argument for a more stringent job matching process.

We envision that the proposed framework in this paper can help foster future work that would study the link between personality and job satisfaction. There have been few studies about such links and we hope that the consideration of the mechanisms we study here can help to inform future studies.

Chapter 3

Higher Intelligence Groups Have Higher Cooperation Rates in the Repeated Prisoner's Dilemma

3.1 Introduction

Intelligence is a controversial concept. We use here the widely accepted definition proposed in a 1996 report by a Task Force created by the Board of Scientific Affairs of the American Psychological Association (Neisser et al., 1996). There, intelligence is defined as "the ability to understand complex ideas, to adapt effectively to the environment, to learn from experience, to engage in various forms of reasoning, to overcome obstacles by taking thought". If this definition is adopted, the relation between intelligence and outcomes for a single individual is natural and clear. Higher intelligence functions, everything else being equal, as a technological factor; it allows larger, faster and better levels of production. This prediction is natural and is also supported by extensive research in psychology and economics (Neal and Johnson, 1996; Gottfredson, 1997; Bowles, Gintis and Osborne, 2001a; Heckman, Stixrud and Urzua, 2006; Jones and Schneider, 2010).

The relation between intelligence and outcomes is less clear when one considers instead the link between intelligence and social behaviour, and wants to explain how the outcomes of groups are influenced. The technological factor becomes less important, since social outcomes depend less on skill compared to the behaviour of others. A conceptual link is missing.

A possible conceptual link between intelligence and behaviour in social situations can be given as a corollary to the general view that intelligence reduces behavioural biases (e.g. Frederick, 2005; Oechssler, Roider and Schmitz, 2009; Dohmen, Falk, Huffman and Sunde, 2010; Beauchamp, Cesarini and Johannesson, 2011; Benjamin, Brown and Shapiro, 2013). For example, higher intelligence may reduce violations of transitivity; or, in choice under uncertainty, the behaviour of subjects with higher intelligence is better described by expected subjective utility. When we apply this intuition to behaviour in strategic environments, we are led to the conjecture that individuals in real life, and subjects in an experiment, who have higher intelligence will exhibit a behaviour closer to the game theoretic predictions. When refinements of the Nash concept are relevant, particularly sub-game perfection, behaviour more in line with the prediction of the refinement for the individual is expected in higher intelligence subjects.

This prediction finds some support when games are strictly competitive (such as the Hit 15 game in Burks et al. (2009)). Recently a related result has been shown by Gill and Prowse (forthcoming) in a repeated beauty contest experiment where more intelligent individuals converge faster to the unique Nash equilibrium demonstrating better analytic reasoning. While these contributions provide important insights in the way cognition affects reasoning on strategic interactions, some important puzzles remain. First, in games that are perhaps more relevant for social behaviour, this prediction fails. This occurs already in the case of one-shot games. In Burks et al. (2009), the authors also study the behaviour of subjects in a sequential trust game. Using a strategy method to identify choices as first and second mover, and relating this behaviour to the intelligence of the subjects, the authors find that initial transfer is increasing with the IQ score; a behaviour which is further from the prediction of the sub-game perfect equilibrium, and so is the opposite of what we should expect according to the general hypothesis. Similarly, transfers as second movers in higher intelligence subjects are higher when the first mover transfers more, and smaller in the opposite case. Since equilibrium behaviour predicts that no transfers should occur in either case, we see that the observed behaviour is inconsistent with the prediction. Secondly, repeated games involving one-to-one interactions generally present a multiplicity of equilibria; games with a unique Nash equilibrium cannot address the crucial issue for the social sciences of how individuals coordinate to one among many possible equilibria.

Some insight into a possible association between intelligence and strategic cooperative behaviour comes from related research in the biological and social sciences. The social intelligence hypothesis (Chance and Mead, 1953; Jolly, 1966; Humphrey, 1976) tries to provide an explanation for differences in the intellectual abilities of animals. The proponents of the theory observe that the evolution of primate intelligence cannot be adequately explained on the basis of different needs to observe, gather and process information in the process of finding food, extracting it, or avoiding predators. Instead, it is the richness of the social interaction that demands the development of the ability to use flexible cognitive strategies to be used in real time, as opposed to adaptive rules of thumb. Later research has provided some support for the general hypothesis. For example, Dunbar (1998) and Dunbar and Shultz (2007) have found a positive correlation between brain size and the size of the network of relations and alliances that an animal species develops.

There is also some early analysis of experimental work that provides support for the hypothesis we test here. Jones (2008) studies the cooperation rates in experiments on repeated prisoner's dilemma games conducted at different universities and the average SAT score at the university at the time in which the experiment was run. He finds that the cooperation rate increases by 5% to 8% for every 100 points in the SAT score. Of course, the evidence is very indirect: students at those universities differ on a large variety of characteristics, and each of them could have been taken as the variable of interest in the correlation. However, such evidence is broadly consistent with the findings we are going to present.

In our experiment we directly test the potential association between intelligence and strategic behaviour in groups. The strategic interaction takes place between two players, but in a pool of people that are relatively homogeneous in their intelligence level. We rely on a well-established methodology in the experimental analysis of repeated games. In particular, we use the same setting as Dal Bó and Fréchette (2011) (henceforth DBF), where they show how by changing the probability of continuation and the payoffs matrix in a repeated prisoner's dilemma game with random probability of termination, subjects may collectively converge to cooperation equilbria; DBF show that in some instances different groups converge to different equilibria for the same set of parameters.

Accordingly, the hypothesis we test is that higher intelligence in a complex environment (such as repeated social interaction) favours a more flexible, effective behaviour, allowing the processing of richer information, so that higher intelligence allows more efficient equilibria to be reached.

We find that subjects in both high Raven and low Raven sessions show a similar rate of cooperation in the initial rounds, the cooperation rate then increases in the high Raven sessions to reach an equilibrium where almost everybody cooperates, while it declines in the low Raven sessions. Subjects in the high Raven sessions increase their level of reciprocation over time, while there is no significant increase in the degree of reciprocation in the low Raven sessions. Intelligence is the only significant determinant of cooperation in the first round choices; other characteristics like personality traits do not seem to play a systematic role.

Furthermore, we use a structural model to estimate the probability of adopting different strategies in the different periods and we find that in the high Raven sessions subjects converge to a probability of two thirds to play a cooperative strategy and zero to play Always Defect. In the low Raven sessions, subjects converge to a probability of playing Always Defect above fifty percent of the times. Consistently with the other results, the probabilities of playing cooperative and non-cooperative strategies at the beginning are roughly similar among subjects in the different Raven sessions. We also show that the cooperation of higher intelligence subjects is payoff-sensitive, and thus not automatic: in a treatment with lower continuation probability there is no difference between different intelligence groups. Finally, we observe that in higher intelligence subjects, cooperation after the initial stages becomes almost immediate, i.e. the default mode; defection instead requires significantly more time. For lower intelligence groups this difference is absent.

Our findings have potentially important implications for policy. While the complex effects of early childhood intervention on the development of intelligence are still currently being evaluated (e.g. Heckman, 2006; Brinch and Galloway, 2012; Heckman et al., 2013), our results suggest that any such effect would have beneficial consequences not just on the personal economic success of the individual, but on the level of cooperation in society. This is a positive consequence that seems to have been overlooked so far. Furthermore, considering the assortative matching between individuals (Becker, 1973; Legros and Newman, 2002) or the tendency to homophily (McPherson, Smith-Lovin and Cook, 2001; Golub and Jackson, 2012) through which people may associate with those who are similar to themselves, the different degrees of cooperation between groups and the resulting different profits achieved may result in a powerful mechanism to magnify inequalities.

To the best of our knowledge, we are the first to analyze the effect of group intelligence on the level of cooperation in a setting with repeated interactions. There is a large experimental literature on the analysis of cooperation with repeated interaction. Cooperation has been shown to be sustainable in experiments with random termination (e.g. Roth and Murnighan, 1978; Holt, 1985; Feinberg and Husted, 1993; Palfrey and Rosenthal, 1994) and also in experiments with fixed termination (e.g. Selten and Stoecker, 1986; Andreoni and Miller, 1993). In experiments with fixed termination, however, the level of cooperation is substantially lower (e.g. Dal Bó, 2005). Other elements can affect cooperation in a repeated interaction. Aoyagi and Fréchette (2009) show that the level of cooperation increases with the quality of the signal if public monitoring is allowed. Duffy and Ochs (2009) find that cooperation increases as subjects gain more experience under fixed matching but not under random matching. DBF show that individuals learn to cooperate after a sufficiently large number of interactions, but only when the benefits of cooperation in the stage game are big enough. Blonski, Ockenfels and Spagnolo (2011) emphasise the effect of the discount factor. All these contributions suggest that the strategies leading to cooperation or defection, in a repeated interaction setting, are extremely complex because they are sensitive to very large number of factors.

Furthermore, strategies leading to cooperation are unlikely to be based on a fixed rule. On the contrary they need to be flexible in the sense of adapting to the circumstances. In this respect, Fudenberg, Rand and Dreber (2010) show that individuals adapt to mistakes when they play their strategy in order to increase the possibility of coordinating on the most profitable cooperative equilibria, while Friedman and Oprea (2012) show that when agents are able to adjust in continuous time, cooperation rates are higher. A continuous time adjustment allows subjects to work in a more flexible environment, where they can quickly adjust in order to cooperate.

All the above-mentioned contributions point out that flexibility and the capacity of adapting to a complex environment are the key factors in allowing partners to cooperate within each other. These characteristics are linked to the definition of intelligence we gave at the beginning.

The literature emphasises how subjects' heterogeneity in terms of different degrees of sophistication determines whether the strategies adopted are more or less rational (e.g. Stahl and Wilson, 1995; Costa-Gomes, Crawford and Broseta, 2001; Costa-Gomes and Crawford, 2006). Our findings are consistent with this literature, but also go a step further by showing that intelligence plays a role in the selection of different Nash Equilibria. Other interesting insights in order to understand our results might come from the so-called "two-systems" theories of behaviour, which emphasise the tension between a long-run, patient self and a short-run, impulsive self (e.g. Bernheim and Rangel, 2004; Loewenstein and O'Donoghue, 2005; Fudenberg and Levine, 2006; Brocas and Carrillo, 2008). If in higher IQ individuals the patient self is stronger, as Burks et al. (2009) imply, cooperation might be the result of a more forward looking behaviour. This could also explain the reason why high Raven groups fail to cooperate in the treatment with lower continuation probability.

This paper is organized as follows: in section 3.2 we present the experimental design and its implementation; in section 3.3 we present the results of the main treatment; section 3.4 provides an analysis of the determinants of cooperation; in section 3.5 we estimate the probability of adopting different strategies in the two Raven sessions; in section 3.6 we present the main results of the treatment with lower continuation probability, hence making cooperation harder; section 3.7 presents the analysis of the response time of the subjects in both treatments. Section 3.8 concludes the paper by providing a general discussion. In appendices C, D and E, we present the timeline of the experiment, the dates and other descriptive statistics respectively. The questionnaire completed at the end by the subjects, the experimental instructions and the recruitment letter circulated are available online as supplementary material.[1]

[1] Available from the page `http://www2.warwick.ac.uk/fac/soc/economics/staff/eproto/workingpapers/supplementary_material.pdf`

3.2 Experimental Design

We allocated participants into two groups according to their level of fluid intelligence measured by the Raven test. The two groups created participated in two separate sessions, defined as *high Raven* and *low Raven* sessions. As we will see below in more detail, apart from two sections we will illustrate at the end, the subjects were not informed on the way the two Raven groups were formed.

They played several repetitions of a repeated prisoner's dilemma game, each repeated game with a new partner. The experiment was run over two days with a time distance of one day between the two sessions. On the first day, the subjects completed the Raven test; on the second day they played the repeated prisoner's dilemma. We ran two different treatments: the main treatment, and another treatment where cooperation is harder. In appendix C, we present the dates and other details of each day one and day two session for both treatments.

Day One

The Raven test

On the first day of the experiment, the participants were asked to complete a Raven Advanced Progressive Matrices (APM) test of 30 tables. They had a maximum of 30 seconds for each table. Before the test, the subjects were shown a table with an example of a matrix with the correct answer provided for one minute. For each item a 3×3 matrix of images was displayed on the subjects' screen; the image in the bottom right corner was missing. The subjects were then asked to complete the pattern choosing one out of 8 possible choices presented on the screen. The 30 tables were presented in order of progressive difficulty and were selected from Set II of the APM.

The Raven test is a non-verbal test commonly used to measure reasoning ability and general intelligence. Matrices from Set II of the APM are appropriate for adults and adolescents of higher average intelligence. The test is able to elicit stable and sizeable differences in performances among this pool of individuals. The correlation between Raven test scores and measures of intellectual achievement suggests that the underlying processes may be general rather than specific to this one test (Carpenter, Just and Shell, 1990). In the economic literature, individuals with higher Raven scores feature a learning process closer to Bayesian updating (Charness, Rustichini and van de Ven, 2011) and have more accurate beliefs (Burks et al., 2009).

Subjects are not normally rewarded for the Raven test. However it has been reported that there is a small increase in Raven scores after a monetary reward is offered to higher than average IQ subjects similar to the subjects in our pool (e.g. Larson, Saccuzzo and Brown, 1994). Since we wanted to measure intelligence with minimum confounding with motivation, we decided to reward our subjects with 1 British pound per correct answer from a random choice of three out of the total of 30 matrices. Always with the aim of minimising confounding with other factors, we never mentioned that Raven is a test of intelligence or cognitive abilities and, for the main treatment, the subjects were never informed that they would be separated on the basis of their performances in this test. We argue below by analysing the distribution of the subjects' characteristics in the two Raven sessions, that confounding is unlikely to be a concern in our experiment and the Raven test allowed the two groups to be separated uniquely according to the subjects' level of cognitive ability.

Other tests and questions

Following the Raven test, the participants were asked to respond to a Holt-Laury task (Holt and Laury, 2002), measuring risk attitudes. The first two experimental sessions reported here did not include the Holt-Laury task. Sessions for the second treatment (where cooperation is harder) did not perform this task either. The participants were paid according to a randomly chosen lottery out of their choices.

Lastly, on the first day participants were asked to respond to a standard Big Five personality questionnaire together with some demographic questions, a subjective well-being question and questions on previous experience with a Raven test. No monetary payment was offered for this section of the session. The subjects were informed of this fact. We used the Big Five Inventory (BFI); the inventory is based on 44 questions with answers coded on a Likert scale. The version we used was developed by John et al. (1991) and has been recently investigated by John et al. (2008).

All the instructions given on the first day are included in the online supplementary material.[2]

Day Two

On the second day, the participants were asked to come back to the lab and they were allocated to two separate experimental sessions according to their Raven scores: subjects with a score higher than the median were gathered in one session, and the remaining subjects in the other. We will refer to the two sessions as *high Raven* and *low Raven* sessions.[3] The task they were asked to perform was to play an infinitely repeated prisoner's dilemma game. In our main treatment the participants played the game used by DBF, who found convergence of full cooperation after the game was repeated for a sufficient number of times in every repetition of the same experiment (see DBF p. 419, figure 1, bottom right-hand diagram).

Table 3.1: **Stage Game:** Prisoner's Dilemma.

	C	D
C	48,48	12,50
D	50,12	25,25

[2]see note 1

[3]The attrition rate was small, and is documented in tables D.1 and D.2 in the Appendix

Following standard practice in the experimental literature, we induced an infinitely repeated game in the laboratory using a random continuation rule: after each round the computer decided whether to finish the repeated game or to have an additional round depending on the realization of a random number. The continuation probability used in the main treatment was $\delta = 0.75$. The stage game used was the prisoner's dilemma game in table 3.1. We also added a second treatment with a lower continuation probability, $\delta = 0.5$, where cooperation is harder. Both the above treatments are identical to the ones used by DBF. They argue that the payoffs and continuation probability chosen in both treatments (i.e. $\delta = 0.75$ and $\delta = 0.5$) entail an infinitely repeated prisoner's dilemma game where the cooperation equilibrium is both sub-game perfect and risk dominant.[4]

The payoffs in table 3.1 are in experimental units; the exchange rate applied to the payoff table was 0.004 British pounds per unit. This exchange rate was calculated in order to equalise the payoff matrix with the monetary units used in the DBF experiment. The participants were paid the full sum of points they earned through all the repetitions of the game. In the main treatment, the first 4 sessions were stopped once 30 minutes had passed and the last repeated game was concluded. For the last 4 sessions, 45 minutes were allowed to pass instead. Concerning the treatment with a lower continuation probability, we ran 4 sessions: two high Raven and two low Raven, all of them stopped once the repeated game was over after 45 minutes. We give more details about this treatment in section 3.6.

The subjects in the high Raven and low Raven sessions played exactly the same game. The only difference was the composition of each group, as for the high Raven sessions the subjects had higher Raven scores compared to those in the low Raven sessions.

Upon completing the Prisoner's Dilemma game, the participants were asked

[4]The sub-game perfect equilibrium set of sub-game perfect equilibria are calculated as in Stahl (1991) and assuming risk neutrality. The risk dominant strategy is calculated using a simplified version of the game assuming only two possible strategies following Blonksi and Spagnolo (2001). See DBF, p. 415 for more details

to respond to a very short questionnaire about any knowledge they had of the Prisoner's Dilemma game. Additionally, in sessions 5-8, the subjects were asked questions about their attitudes to cooperative behaviour and some strategy-eliciting questions.

Implementation

We conducted a total of 8 sessions for the main experiment, with high continuation probability; four high Raven and four low Raven sessions. There were a total of 130 participants, with 66 in the high Raven and 64 in the low Raven session. The lower continuation probability treatment was conducted in 4 sessions with 60 subjects: 30 in the high Raven and 30 in the low Raven session.

All the participants were recruited from the subject pool of the Warwick experimental laboratory. The participants in the last six sessions of the main treatment did not include economics students. The participants in these non-economist sessions had not taken any game theory modules or classes. The recruitment was conducted with the DRAW (Decision Research at Warwick) system, based on the SONA recruitment software. The recruitment letter circulated is in the supplementary material. The dates of the sessions and the number of participants per session, are presented in appendix D in tables D.1 and D.2.

As already noted at the beginning of this section, to allocate participants in the two Raven sessions for Day Two they were first ranked according to their Raven score. Subsequently, the participants were split into two groups. In cases where there were participants with equal scores at the cutoff, two tie rules were used based on whether they reported previous experience of the Raven task and high school grades. Participants who had done the task before (and were tied with others who had not) were allocated to the low Raven session, while if there were still ties, participants with higher high school grades were put in the high session.

Table 3.2: **Raven Scores by Sessions**

Variable	Mean	Std. Dev.	Min.	Max.	N
High Raven - Session 1	20.429	1.505	18	23	14
Low Raven - Session 2	14.063	3.395	6	18	16
High Raven - Session 3	19	2	16	23	18
Low Raven - Session 4	13.188	1.94	10	16	16
High Raven - Session 5	20.444	1.79	18	24	18
Low Raven - Session 6	14.167	3.538	7	18	12
High Raven - Session 7	20.688	2.243	18	25	16
Low Raven - Session 8	15.75	1.372	13	18	20

Table 3.2 summarises the statistics about the Raven scores for each session. In the main treatment, for all but sessions 3 and 4 the cutoff Raven score was 18. In sessions 3 and 4 the cutoff was 16 because the participants in these sessions scored lower on average than the rest of the participants in all the other sessions (mean Raven score for sessions 3 and 4: 15.69, while the mean Raven score for all sessions: 17.89). Figure 3.1 presents the total distribution of the Raven scores and the distributions in the separate Raven sessions (in appendix E, tables E.1 and E.2 present a description of the main data in the low and high Raven sessions respectively, and table E.7 shows the correlations among individual characteristics).

The subjects on average earned 17.05 GBP (about 28 USD); the participation payment was 4 GBP. The software used for the entire experiment was Z-tree (Fischbacher, 2007). The Ethical Approval of this design was granted by the Humanities and Social Sciences Research Ethics Sub-Co at the University of Warwick under DRAW Umbrella Approval (Ref: 81/12-13).

A detailed timeline of the experiment is presented in appendix C and all the

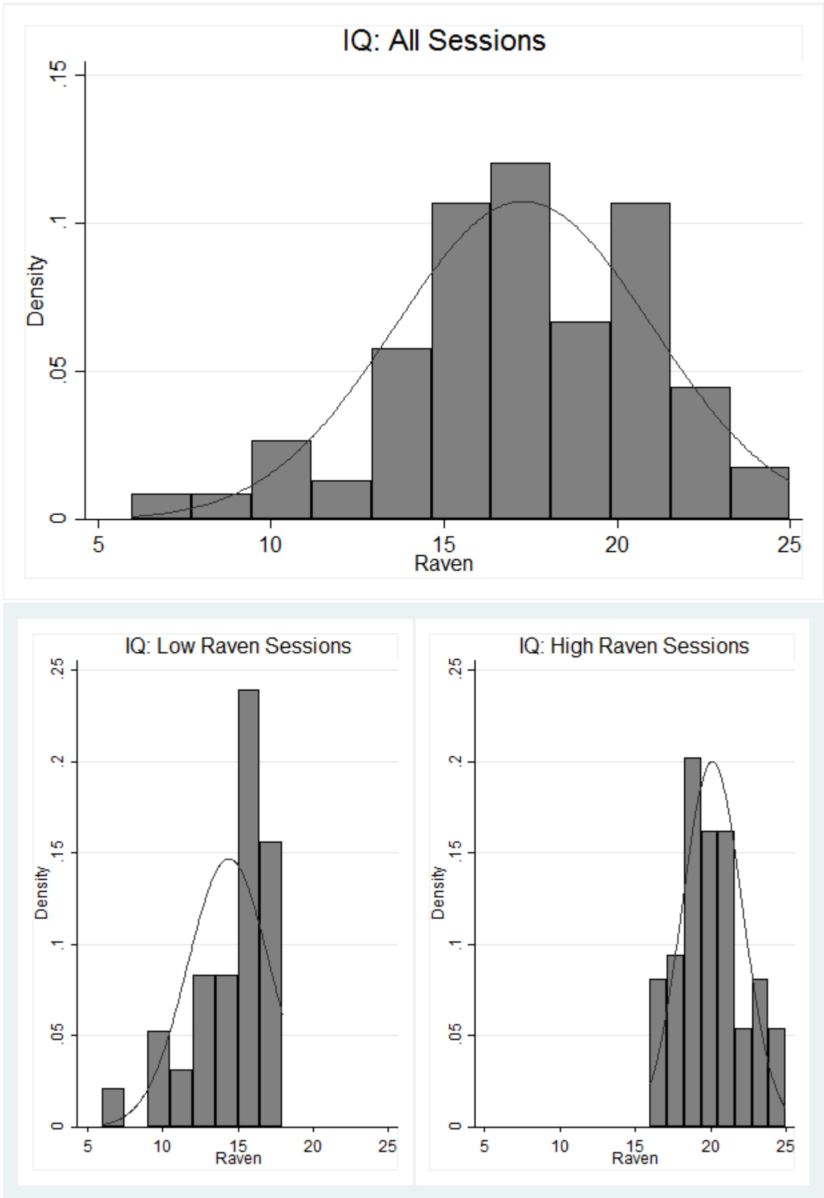


Figure 3.1: **Distribution of the Raven Scores for the main treatment.** The top panel depicts the distribution of the entire sample. The bottom panel presents the distributions in the separate Raven sessions.

Table 3.3: **Differences between the means of the main variables in the high and low Raven sessions.**

Variable	Low Raven	High Raven	Differences	Std. Dev.	N
Age	22.35938	21.24242	1.116951	.7251282	130
Female	.625	.5	.125	.0870282	130
Openness	3.642188	3.595455	.0467329	.1016391	130
Conscientiousness	3.399306	3.405724	-.0064184	.1198434	130
Extraversion	3.349609	3.244318	.1052912	.1308186	130
Agreeableness	3.840278	3.765993	.0742845	.1060675	130
Neuroticism	2.910156	2.835227	.074929	.1361939	130
Raven	14.39063	20.10606	-5.715436***	.4170821	130
Economist†	.25	.5714286 .	-.3214286*	.1753537	30
Risk Aversion	5.5625	5.5	.0625	.2865234	100
Final Profit	2774.297	4675.303	-1901.006***	258.9902	130
Periods	83.3125	116.4848	-33.17235***	5.039728 2	130
Profit × Period	33.26863	38.546693	-5.278058***	.8951038	130

† only sessions 1 and 2

instructions and any other pertinent documents are available online in the supplementary material.[5]

3.3 Cooperation with high discount

This section focuses on describing the results of the main treatment, with high continuation probability, $\delta = 0.75$.

Different degrees of cooperation in the high and low Raven sessions

Table 3.3 shows that the samples in the high and low Raven sessions have similar characteristics. Only the differences in the Raven score are statistically different at the 5% confidence level. Overall we can say that the subjects in the high and low Raven sessions differ only in their intelligence. The two groups are similar in terms of personality. In particular, there is no difference in the conscientiousness score.[6]

[5] See note 1

[6] This is true even when we consider a non parametric test. The Kolmogorov-Smirnov test for equality of distribution functions cannot reject the hypothesis that the distribution of conscien-

This lends support to the fact that motivation had a negligible effect on the Raven scores, as is reasonable for subjects with higher than average cognitive ability. If this were not true, subjects with low level of conscientiousness would disproportionately belong to the low Raven sessions.[7]

A similar argument applies to the possibility that anxiety to perform well in the Raven test might have affected the performances of some subjects; if this were true more neurotic subjects should have performed worse.[8] From table 3.3 we can observe that the average level of neuroticism in the two groups is not statistically different.[9]

There is a large difference in the performances in the two Raven sessions (table 3.3). The final average earnings in the low Raven sessions are almost half the amount earned by the participants in the high Raven sessions. The better results of the subjects in the high Raven sessions were obtained both because they played more rounds per session and because they coordinated in more efficient equilibria in each round.

In sessions 1 and 2, there was a large difference in the proportion of economics students: one half in session 1 (high Raven), but only one fourth in session 2 (low Raven). The better performances in the Raven score for the economics students is probably a characteristic of Warwick University, where the entrance requirement for economics is more selective than for other subjects. If economists were more likely to play cooperation equilibrium in the prisoner's dilemma, it could have represented a potential confounding factor. For this reason, we excluded the economists and all subjects that declared they had taken a course of game theory when we sent the

tiousness is the same in the two groups with a $p - value = 0.985$.

[7]Conscientiousness is usually defined as: *"The degree to which a person is willing to comply with conventional rules, norms, and standards.* The trait is usually measured by survey questions, some of them explicitly asking subjects to report reliability and care in work. The entire questionnaire is in the supplementary material.

[8]Neuroticism is associated with anxiety and fear of failing. Some of the statements contributing to the neuroticism score are: Is relaxed; handles stress well (R); Can be tense; Worries a lot; Remains calm in tense situations (R); Gets nervous easily.

[9]The Kolmogorov-Smirnov test for equality of distribution functions cannot reject the hypothesis that the distribution of neuroticism is the same in the two groups with a $p - value = 0.780$.

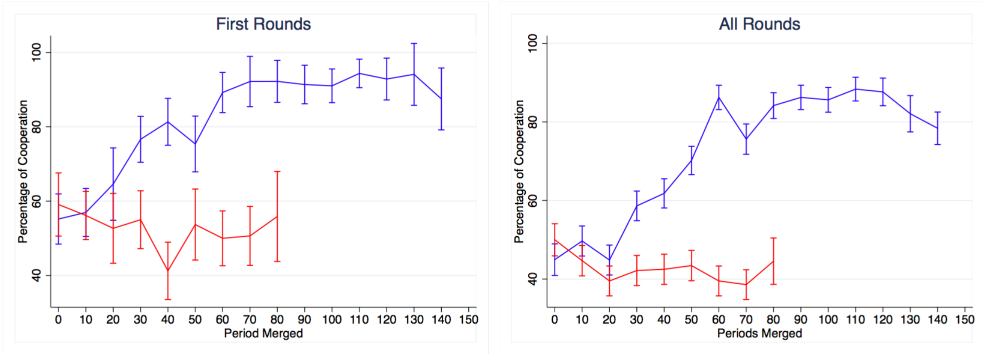


Figure 3.2: **Cooperation per period in the low and high Raven sessions.** The two panels report the averages computed over observations in successive blocks of ten rounds of all high and all low Raven sessions, aggregated separately. The top panel reports the average of cooperation in the first round (of a repeated game) that occurs in the block and the bottom the average of cooperation for all rounds of the game in that block. The bands represent 95% confidence intervals.

invitation to recruit subjects for sessions 3 to 8. It will become clear later that there is no qualitative difference between the sessions with and without economists.

Cooperation rates by Raven sessions over time

In our experiment, the subjects played several instances of a repeated game, each repeated game entailing a sequence of rounds. To take into account the order position of a round in the session, we numbered it as a period to take into account the rounds that had already taken place but belonged to an earlier repeated game. For example, the first round of the second repeated game in a session where the first game lasted seven rounds is labelled period 8.

In figure 3.2 we present the evolution of cooperation in the low and high Raven sessions. Each point on the line represents the proportion of subjects cooperating in blocks of 10 rounds. We took the averages over Raven sessions of the same type (high and low respectively). After the first two blocks (20 rounds overall), where there is no significant difference between the two types of Raven sessions, the cooperation rate clearly diverges: the rate in the high Raven sessions increases whereas in the low Raven sessions it declines. This is confirmed by table 3.4, showing in columns 1 and 2 that there is a significant difference in the trend of cooperation between the two Raven sessions, in column 3 that the odds of cooperating significantly increase 1.7% per period in the high Raven sessions, and in column 4 that cooperation slightly decreases in the low Raven sessions (note that throughout the paper the coefficients of the logit estimations will always be expressed in odds ratios).

Table 3.4: **Trends of cooperation in the high and low Raven sessions.**

	Logit FE All	OLS FE All	Logit FE High Raven	Logit FE Low Raven
Period	0.9945***	–0.0009***	1.0178***	0.9945***
	(0.0014)	(0.0002)	(0.0009)	(0.0014)
H.Rav*Period	1.0234***	0.0031***		
	(0.0017)	(0.0002)		
r2		0.028		
N	12640	13020	7468	5172

Note: The dependent variable is the choice of cooperation per individual. Coefficients in columns 1, 3 and 4 are expressed as odds ratios. Standard errors in brackets. * $p-value < 0.1$, ** $p-value < 0.05$, *** $p-value < 0.01$.

The left panel of figure 3.2 depicts only the aggregated first rounds of each repeated game. Looking separately at the first rounds is important since different repeated games may result in a different number of rounds, and the percentage of cooperation may vary across rounds.

Figure 3.3 presents a different aggregation of the rounds and repeated games. The top panel shows no differences in the first repeated games. The bottom panel shows that the average cooperation considering all the rounds is significantly higher in the high Raven sessions. In particular, in the first round of each repeated game it is nearly 80%, while in the low Raven session it is just above 50%. As stated above, there is no difference in cooperation when the individuals started playing. The difference is entirely due to learning.

Figure 3.4 shows that the same pattern is replicated in each pair of contiguous sessions. In sessions 3 and 4 (top right-hand panel) the divergence is less

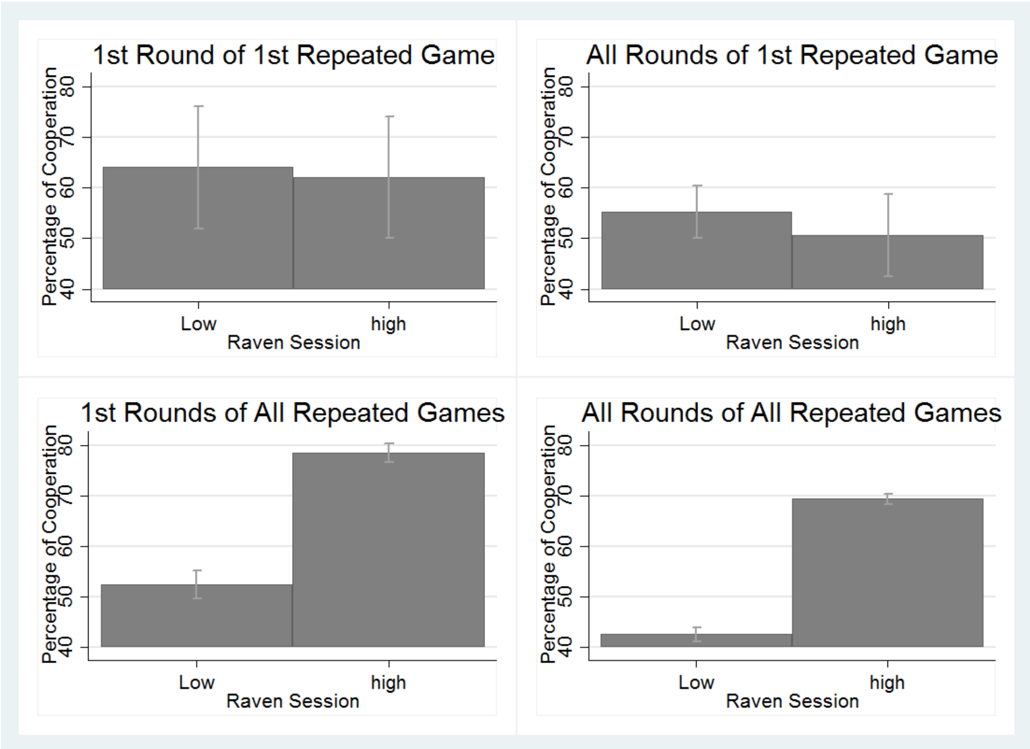


Figure 3.3: **Average cooperation in the low and high Raven sessions**
The histograms represents the average cooperation in each session. Top panel: first repeated game; bottom panel: all games. The bands represent 95% confidence intervals.

significant.[10] However, the solid black line in the figure, representing the *lowess* estimate, shows that divergence was starting to take place around the 30th round, consistent with the other sessions.[11] We conclude this section with the following:

Result 3.3.1. *The subjects in both the high Raven and low Raven sessions show a similar rate of cooperation in the initial rounds. Cooperation then increases in the high Raven sessions to almost full cooperation, while it slightly declines in the low Raven sessions.*

[10]This is due in part to the fact that in session 3 a particularly slow subject prevented the group from playing a sufficiently large number of repeated games. Also recall that this session was set to last 30 minutes.

[11]Considering the bottom right-hand figure, we note a decline in cooperation in session 7. This is possibly due to the fact that the subjects might have started to understand that the experiment was coming to a close, so it could be an end of game effect- the last repeated game of this session lasted unusually longer.

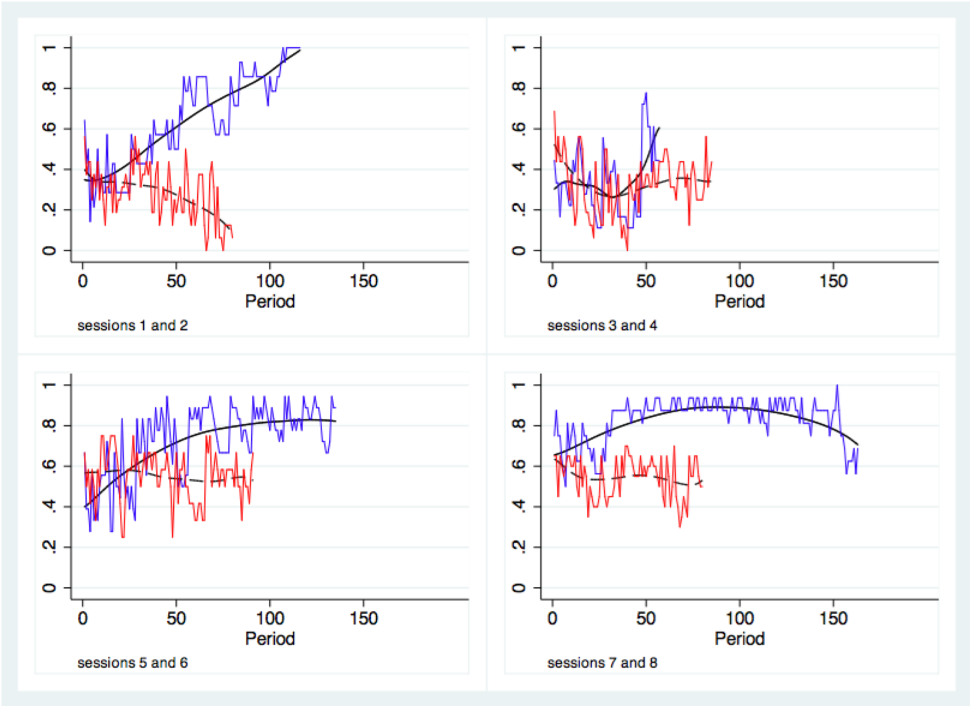


Figure 3.4: **Cooperation per period in all the different sessions.** The red lines represent the low Raven sessions and the blue lines represent the high Raven sessions. The black lines represent the lowess estimator.

3.4 Determinants of the degree of cooperation

In what follows we analyse the mechanisms that lead to the different patterns of cooperation in the two Raven sessions.

Effect of partners' choices

In figure 3.5, we plot the level of cooperation conditional on the partners' choice over different periods. The figure reports the evolution of the choice of cooperation when the partner cooperated the previous round, and the choice of cooperation after the partner's defection in the previous round. From the top left-hand panel of figure 3.5, we conclude that in the high Raven sessions, the subjects evolved to reciprocate cooperation. In the last few periods, reciprocation occurs almost always. In the low Raven sessions, individuals reciprocate cooperation significantly less, and the learning effect is less steep. There is no difference in the first period, so the subjects in the high Raven group learn to reciprocate faster than in the low Raven. From the bottom left-hand panel we note that the subjects in the high Raven sessions reciprocate cooperation 20 % more often than the low Raven ones.

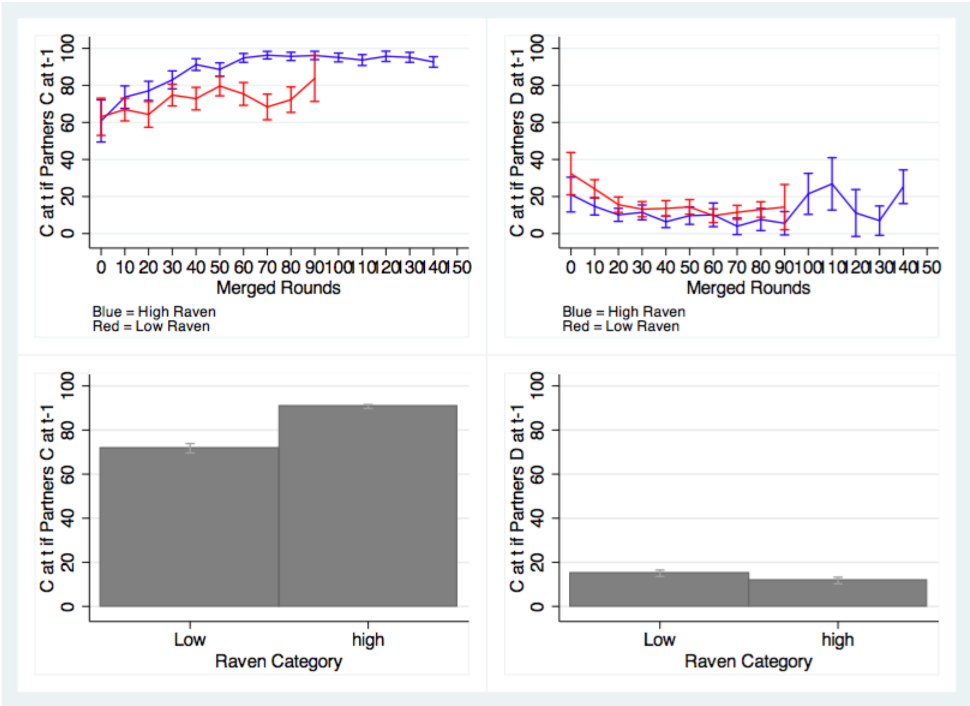


Figure 3.5: **Conditional cooperation per period in the high and low Raven sessions.**

Left-hand panels: cooperation choice by the subject at t after a cooperation choice by the other player at $t-1$. Right-hand panels: cooperation choice after a defection choice by the other player at $t-1$. The red lines represent the low Raven sessions and the blue lines represent the high Raven sessions. The bands represent 95% confidence intervals.

In the top right-hand panel we note a tendency to decrease the rate of cooperation when the partner defects. In other words, the subjects learn to forgive less in general. Again this reciprocation is stronger for the high Raven than for the low Raven sessions, although this difference is much smaller than the reciprocation of cooperation (bottom right-hand panel).

In table 3.5, we investigate further the way subjects learn to reciprocate. We estimate how the cooperation choice of a player (say player 2) in round 1 induces

Table 3.5: **Effects of past partners' choice on cooperation.**

	All 2^{nd} Rounds	All 2^{nd} Period	Hig Raven 2^{nd} Rounds	Low Raven 2^{nd} Rounds
Partner Ch.$[t-1]$	6.2396***	2.5412**	7.0759***	6.2396***
	(2.2876)	(1.1483)	(2.2589)	(2.2876)
H.Rav.*Partner Ch.$[t-1]$	1.1340	1.3458		
	(0.5513)	(0.6771)		
Partner Ch.$[t-1]$*Period	1.0126		1.0395***	1.0126
	(0.0078)		(0.0066)	(0.0078)
H.Rav.*Partner Ch.$[t-1]$*Period	1.0265***			
	(0.0102)			
Period	0.9854**		0.9980	0.9854**
	(0.0058)		(0.0047)	(0.0058)
H.Rav.*Period	1.0128*			
	(0.0077)			
r2				
N	2153	112	1383	770

Note: The dependent variable in columns 1, 3 and 4 is the choice of cooperation per individual, in the second round of each repeated game. The dependent variable in column 2 is the choice of cooperation per individual in the second round of the first repeated game (if this exists and the game did not terminate at round 1). Coefficients are expressed in terms of odds ratio. Standard errors in brackets. * $p-value < 0.1$, ** $p-value < 0.05$, *** $p-value < 0.01$.

the same choice for her partner (say player 1) in round 2. The choice of player 1 in round 2 of a repeated game can be influenced by player 2's choice in round 1. Player 2's choice in round 1 is clearly independent of the choice of player 1 since the action is simultaneous. Hence, the coefficient of player 2's choice in round 1 over player 1's choice in round 2 can be reasonably considered an unbiased estimator of the way individuals reciprocate cooperation.

Column 1 of table 3.5 shows that individuals increase the level of reciprocation over time significantly more in the high Raven sessions, while in the low Raven sessions the reciprocation does not significantly increase. Column 2 shows that there is no significant difference between the two Raven sessions in the level of reciprocation in the first repeated game in period 2. Hence, columns 1 and 2 show that the subjects start from a similar level of reciprocation but learn to reciprocate over time only in the high Raven sessions. Column 3 suggests that the odds of reciprocating in the high Raven sessions increase to about 4% in each period. Once this is taken into account there is no significant increase in cooperation due to the general trend. Column 4 shows that the level of reciprocation does not change significantly in the low Raven sessions. Still from column 4, we can observe again that the sign of the coefficient of the trend (Period) is negative and significant in the low Raven sessions.

We summarise the results from this session with the following:

Result 3.4.1. *The degree of reciprocation in the subjects belonging to the high Raven sessions increases over time; there is no significant increase in the degree of reciprocation in the low Raven sessions.*

Effect of Individual characteristics

Table 3.6 presents the effect of the individual characteristics in the cooperation choice. We consider only the choice in the first round of a repeated game to abstract from the effect of the partner's choice. From column 1, we note that only intelligence, measured in terms of score in the Raven test, is a significant predictor of cooperation, at least at the 5% level.[12] None of the Big Five personality traits, risk aversion or gender have a significant effect on cooperation at the 5% level in the first rounds of the repeated games. In column 2, we only consider the first round of the first repeated game (hence period 1 only), thus abstracting from the experience of interaction with the other players. Consistently with what was noted above, intelligence has no impact on the first-period behaviour. In conclusion, the higher level of cooperation we observe in the high Raven sessions is the outcome of a cumulative process rather than of a characteristic that produces cooperation independently of experience.

After controlling for the Raven scores, the dummy indicating the high Raven sessions is not significant, suggesting that it is the individual intelligence more than

[12]Sessions 1 and 2 are excluded because in these two initial sessions we did not measure the subjects' risk aversion. Including them would not change our conclusions

Table 3.6: **Effects of IQ and other characteristics on cooperation.**

	OLS 1^{st} Rounds	Logit 1^{st} Period	OLS 1^{st} Rounds HR	OLS 1^{st} Rounds LR
Raven	0.0333**	0.9768	0.0389*	0.0376
	(0.0166)	(0.1062)	(0.0228)	(0.0246)
Openness	0.0563	0.7234	0.0799	0.0237
	(0.0744)	(0.3229)	(0.0952)	(0.1246)
Conscientiousness	–0.0089	1.1203	–0.0175	–0.0165
	(0.0536)	(0.4062)	(0.0523)	(0.0999)
Extraversion	–0.0507	1.3014	–0.0687	–0.0696
	(0.0651)	(0.4549)	(0.0719)	(0.0933)
Agreeableness	–0.1041*	0.8327	–0.0380	–0.2124*
	(0.0595)	(0.3301)	(0.0721)	(0.1056)
Neuroticism	0.0119	0.9899	0.0885	–0.1030
	(0.0574)	(0.3481)	(0.0706)	(0.0945)
Risk Aversion	0.0114	0.9801	0.0414	–0.0700
	(0.0278)	(0.1603)	(0.0309)	(0.0570)
Female	–0.1301	0.3828*	–0.2079**	0.0207
	(0.0896)	(0.2062)	(0.0985)	(0.1537)
Age	–0.0048	1.0470	–0.0178	–0.0047
	(0.0063)	(0.0712)	(0.0123)	(0.0099)
High Raven Session	–0.0715	0.8139		
	(0.1319)	(0.5828)		
r2	0.163		0.290	0.148
N	100	98	52	48

Note: The dependent variable in columns 1, 3, 4 is the share of cooperative choices in the first rounds of all repeated games. The dependent variable in column 2 is the cooperative choice per individual in the first round of the first repeated game. Columns 3 and 4 respectively refer to all first rounds in the high and low Raven sessions separately. All coefficients in column 2 are expressed in terms of odds ratio. (Robust) Standard errors in brackets (in columns 1, 3, 4); * $p-value < 0.1$, ** $p-value < 0.05$, *** $p-value < 0.01$

the session effect (due to the fact that individuals play with more intelligent individuals) which drives the effect on cooperation. This finds further support from the fact that the size of the two coefficients measuring the effect of the Raven scores presented in columns 3 and 4 of table 3.6 are similar in the two Raven sessions.

We conclude this section with the following:

Result 3.4.2. *Intelligence is the only significant determinant of cooperation in the first round choices. In the first round of the first repeated game there is no difference between the two groups. Hence, this effect is produced by the learning of the subjects in the sequence of repeated games.*

3.5 Strategies in the different Raven sessions

In the previous section, we showed how past partners' choices affects subjects' choices in the two Raven sessions; here we analyse the strategies used in the two sessions. We follow DBF, restricting our attention to a finite set of common and natural strategies. In particular, we consider the six strategies listed in table 3.7. They have been chosen with respect to their importance in the theoretical literature: Always Cooperate (AC), Always Defect (AD), Grim (G), Tit for Tat (TFT), Win Stay Loose Shift (WSLS) and a trigger strategy with two periods of punishment (TFT, after D C C).[13]

The likelihood of each strategy is estimated by maximum likelihood, assuming that the subjects have a fixed probability of choosing one of the six strategies in the time horizon under consideration. We focus on the last 5 (columns 1 and 2 of table 3.7) and first 5 interactions (columns 3 and 4 of table 3.7). We assume that the subjects may make mistakes and choose an action that is not recommended by the strategy they are following. The likelihood that the data corresponds to a given strategy was obtained by allowing the subjects some error in their choices in any round, where by error we mean a deviation from the prescribed action according to their strategy. A detailed description of the estimation procedure is in the online Appendix of DBF.[14]

We first consider the final strategies played at the end of the session, specifically the last 5 games. The low Raven subjects play Always Defect with a probability above 50%, in stark contrast with the high Raven subjects, who play this strategy with a probability statistically equal to 0. Instead, the probability for the high Raven of playing more cooperative strategies (Grim and Tit for Tat) is about 67%, while for the low Raven ones this is lower (around 45%).

[13]In appendix E in table E.8, following Dal Bó and Fréchette (2013), we present the same exercise with 12 possible strategies. Our conclusions remain qualitatively the same.

[14]See p. 6-11, available online at `https://files.nyu.edu/gf35/public/print/Dal_Bo_2011a_oa.pdf`

Table 3.7: **Individual strategies in the different Raven sessions in the last 5 and first 5 repeated games**

Raven Session Repeated Games	High Last 5	Low Last 5	High First 5	Low First 5
Strategy				
Always Cooperate	0.0886	0.0348	0	0.0745
	(0.1041)	(0.0574)	(0.0402)	(0668)
Always Defect	0.0417	0.5148***	0.3395***	0.3415***
	(0.0354)	(0.1049)	(0.1076)	(0.0967)
Grim after 1 D	0.3705***	0.1522**	0.6605***	0.2180***
	(0.1429)	(0.0617)	(0.1248)	(0.0783)
Tit for Tat (C first)	0.2976**	0.2982***	0	0.3540***
	(0.1418)	(0.0846)	(0.1175)	(0.0857)
Win Stay Lose Shift	0.0701	0	0	0.0121
	(0.1289)	(0.0306)	(0.0545)	(0.0473)
Tit For Tat (after D C C)†	0.1315	0	0	0
Gamma	0.3249***	0.4146***	0.5313***	0.6312***
	(0.0774)	(0.0381)	(0.0662)	(0.0525)
beta	0.956	0.918	0.868	0.830
Sessions	1,5,7	2,4, 6, 8	1,5,7	2,4,6, 8
Average Rounds	4.83	5.12	2.11583	3.875
N. Subjects	48	64	48	64
Observations	1090	1676	518	1152

Notes: Each coefficient represents the probability estimated using ML of the corresponding strategy. Std error is reported in brackets. Gamma is the error coefficient that is estimated for the choice function used in the ML and beta is the probability estimated that the choice by a subject is equal to what the strategy prescribes.†† Tests equality to 0 using the Waldtest: * $p-values < 0.1$, ** $p-values < 0.05$ **, $p-values < 0.01$ ***
† Tit for Tat (after D C C) stands for the Tit for Tat strategy that punishes after 1 defection but only returns to cooperation after observing cooperation twice from the partner.
†† When beta is close to 1/2, choices are essentialy random and when it is close to 1 then choices are almost perfectly predicted.

The strategies used in the initial rounds are quite similar across the two groups (see columns 3 and 4), consistent with our earlier finding that the cooperation rates are similar across Raven sessions in the initial periods. Both groups play at the beginning Always Defect with a probability about 34% and more cooperative strategies (Grim and Tit for Tat) with a probability of about 66% for high Raven subjects and 57% for low Raven ones.

We summarise the main findings of this section in the following:

Result 3.5.1. *In the high Raven sessions, the subjects converge to a probability of* *two thirds for playing a cooperative strategy and never play Always Defect. In the low Raven sessions, the subjects converge to a probability of playing Always Defect with a probability of just above one half. The probabilities of playing cooperative and non-cooperative strategies at the beginning are roughly similar among the subjects in the different Raven sessions.*

3.6 Cooperation with low discount

Cooperation is harder with a lower continuation probability. In this treatment we set $\delta = 0.5$, while the payoff matrix in the stage game is the same as in the main treatment (as in table 3.1). Accordingly, differently from the case of $\delta = 0.75$, the experimental results of DBF when $\delta = 0.5$ show no evidence of convergence to cooperation (see DBF, p. 419, figure 1, top right-hand diagram). The scope of this treatment is then to test how cognitive skills affect the pattern of cooperation of the group when cooperation is harder.

As in the main treatment, the subjects were divided into low and high Raven sessions according to their Raven scores. We ran 4 sessions; 2 of them with high Raven (numbered 1ld and 3ld) and 2 low Raven (2ld and 4ld). Every session was stopped once 45 minutes had passed and the last repeated game was concluded. The high Raven session 3ld and the low Raven session 4ld are exactly like the main treatment, the only difference being the continuation probability. In the high Raven session 1ld and the low Raven session 2ld, there is a difference in the information given to the subjects. At the beginning of the session on day 2, they received, their Raven score and the summary statistics of the Raven scores of the participants in their respective sessions on a piece of paper. Hence, subjects were informed about the way they had been allocated in the Raven sessions. This treatment aimed to test whether when subjects are aware that their partner's cognitive skills are similar to their own they coordinate better.

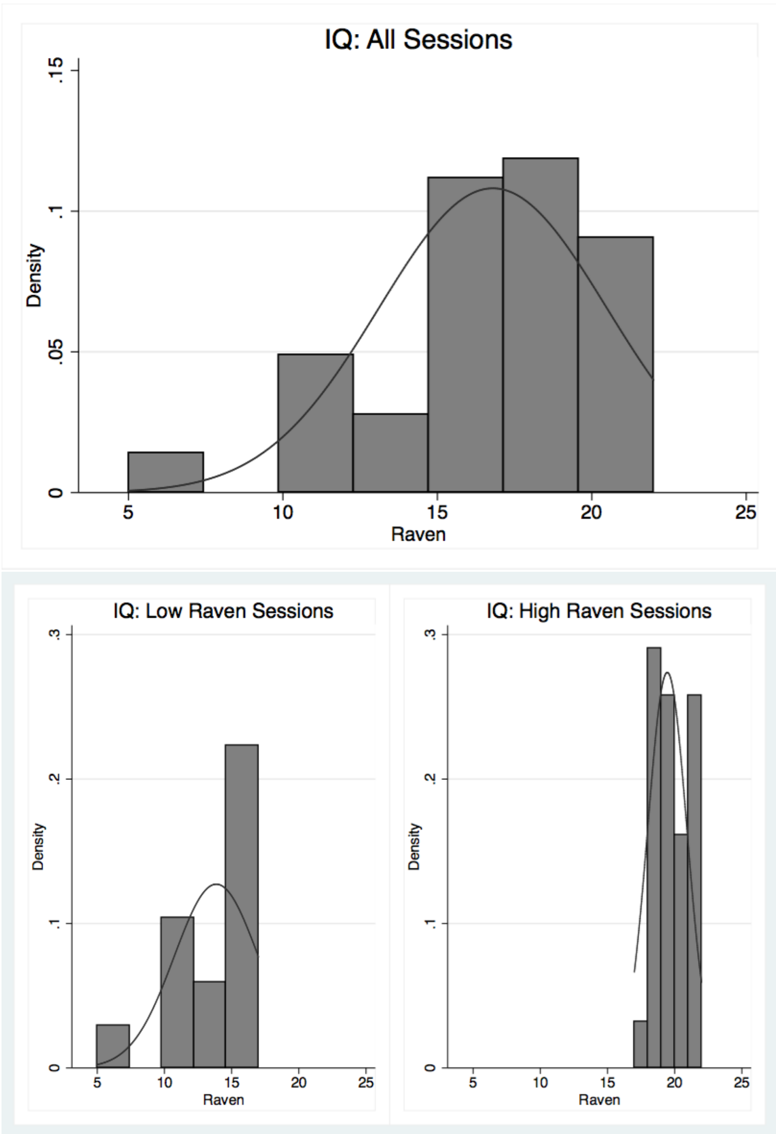


Figure 3.6: **Distribution of the Raven scores in the low discount treatments.**
The top panel depicts the distribution of the entire sample. The bottom panel presents the distributions in the separate Raven sessions.

The dates of the sessions of this treatment with low discount and the descriptive statistics of the main variables are in table D.2 and tables E.3-E.6 in appendices D and E. Figure 3.6 presents the total distribution of the Raven scores and the distributions in the separate Raven sessions for the subjects in this treatment.[15]

From figure 3.7, we cannot observe any convergence to full cooperation in either Raven session or in either treatment. Hence both Raven sessions are similar in this respect to the corresponding sessions in DBF. On the contrary, there seems to be a decline in both Raven sessions.[16] This is true in the sessions where we informed individuals about the allocation (1ld and 2ld) and in the sessions where we did not give this information (3ld and 4ld).

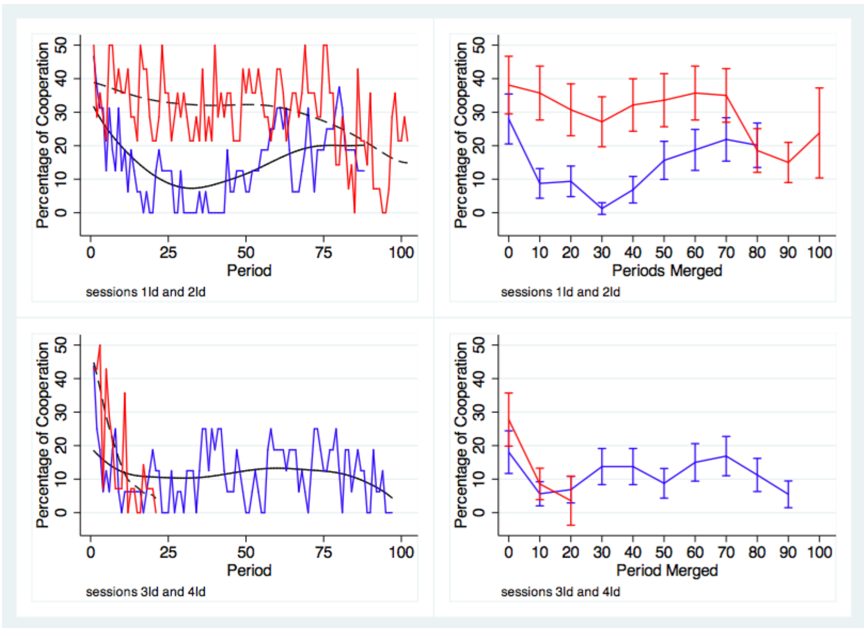


Figure 3.7: **Cooperation per period in the low and high Raven sessions with low discount.**

The red lines represent the low Raven sessions and the blue lines represent the High Raven Sessions. In the left-hand panels, the black lines represent the lowess estimator. The two right-hand panels report the averages computed over observations in successive blocks of ten rounds of all high and all low Raven sessions, aggregated separately. The bands represent 95% confidence intervals.

[15]The distribution of other characteristics is similar in the two Raven sessions in this series of experiments as well. A formal test like the one performed for the main treatment in table 3.3 is available upon request.

[16]Session 4ld had to be stopped because a subject in period 24 shouted:"Lets Cooperate!". There was no reason to exclude the data previously collected.

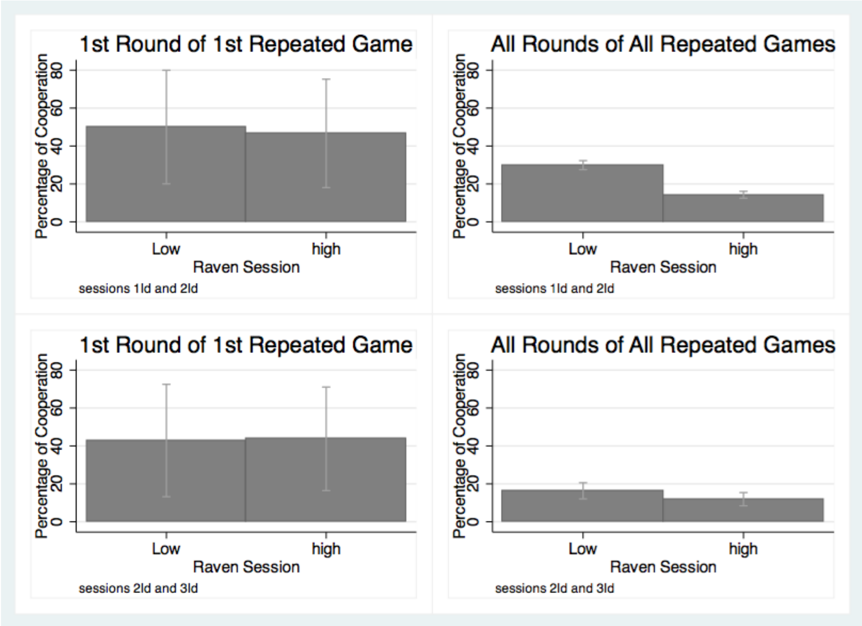


Figure 3.8: **Average cooperation in the low and high Raven sessions with low discount**

The histograms represent the average cooperation in each session. The top panels represent sessions 1ld and 2ld, where the subjects are informed about the way the Raven sessions were formed. The bottom panels represent sessions 3ld and 4ld where – as in the main treatment with high discount– the subjects are not informed. For sessions 3ld and 4ld only the first 20 rounds have been considered. The bands represent 95% confidence intervals.

Furthermore, we note that after the first block (10 rounds overall), where there is no significant difference between the two types of Raven sessions, the cooperation rates seem to diverge. In both cases they decline, but the decline seems faster in the high Raven sessions. In figure 3.8, we can observe the average level of cooperation in the different Raven sessions and in the treatments with (sessions 1ld and 2ld) and without information (sessions 3ld and 4ld). In the treatment without information we only considered the first 20 periods for the sake of comparability between the two Raven sessions.[17] Figure 3.8 confirms the findings in figure 3.7: *(i)* Average cooperation overall is significantly lower than the cooperation in the first period in both Raven sessions and in both treatments (with and without information); *(ii)* the initial level of cooperation is similar in the two Raven sessions; *(iii)*

[17]Recall that the low Raven session in this treatment had to be stopped after 20 rounds, see note 16.

in the low Raven sessions individuals cooperate more in average, this difference is significant in the session with information and borderline insignificant, at the 5% level in the sessions without information.

Figure 3.9 can provide an explanation of why the low Raven subjects cooperate more in this treatment. From the top left-hand panel of this figure, we note that there is no significant difference in the way the subjects react to the cooperative choice of the partner. Comparing this with the corresponding panel in figure 3.5 (top left-hand panel), we can argue that the subjects in the high Raven sessions do not seem to learn to reciprocate cooperation as they do in the main treatment. At the same time, from the top right-hand panel of figure 3.9, we can observe that in the low Raven session the subjects seem to cooperate more after defection by the partner for most of the session. The two groups seem to converge only at the end. This can then explain the difference in the average cooperation we observed in the two groups. Some subjects in low Raven session kept cooperating even after the partners defected for most of the session, and they learnt that this was not leading to more cooperation only toward the end. Hence, it is possible to argue that low Raven subjects need more time to predict other subjects' reactions. Finally, note that for completeness we have reported the results of the sessions with no information in the panels at the bottom of figure 3.9, from which we note that the pattern in the high Raven session is not dissimilar to the one with information.

We summarise the main findings of this section in the following:

Result 3.6.1. *With lower continuation probability the degree of cooperation declines over time in both the low and high Raven sessions.*

A final consideration in this section concerns the effect of the information. A natural conjecture is that when subjects are informed that they will be playing with individuals with a similar level of cognitive ability, they should be able to coordinate better.

From figure 3.8, we note that the availability of this information does not

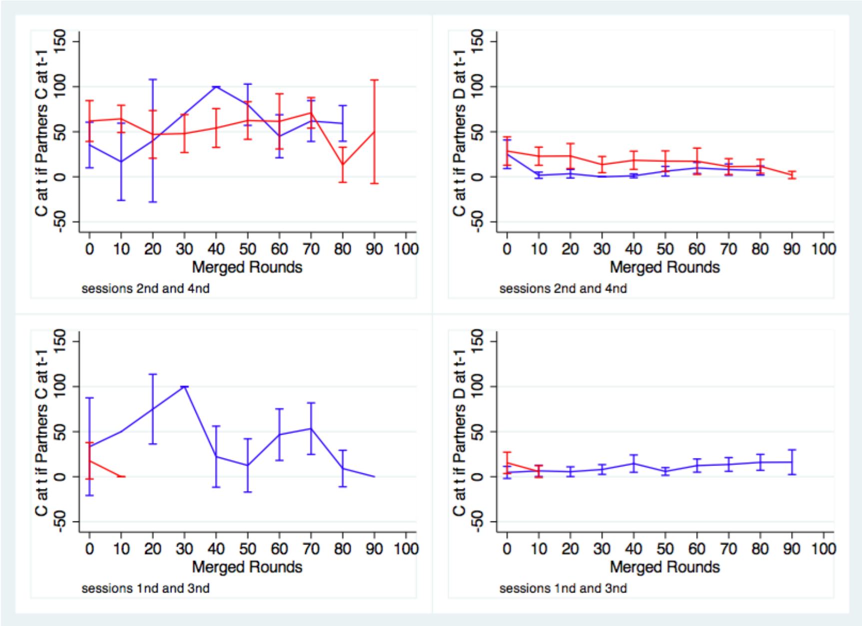


Figure 3.9: **Conditional cooperation per period in the high and low Raven sessions with low discount**

Left-hand panels: cooperation choice of the subject at t after a cooperation choice by the other player at $t-1$. Right-hand panels: cooperation choice after a defection choice by the other player at $t-1$. The bottom panels represent sessions 3ld and 4ld where – as in the main treatment with high discount– the subjects are not informed. For sessions 3ld and 4ld only the first 20 rounds have been considered. The red lines represent the low Raven sessions and the blue lines represent the high Raven sessions. The bands represent 95% confidence intervals.

lead any group to coordinate to an equilibrium with a high level of cooperation. However, in both the high and low Raven sessions, the average cooperation is significantly higher in the treatment with information. More specifically, in the low Raven session with information there are 29.9% cooperative choices, while in the one with no information, there are 16.3% cooperative choices in the first 20 rounds (we consider only the first 20 rounds to make this session comparable with the corresponding session with information, which we recall, had to be prematurely stopped), significantly lower with a $p-value < 0.01$; in the high Raven session with information, the percentage of cooperative choices is 11.9% with no information and 16.9% when the information was given. This last number is significantly higher with a $p-value < 0.05$.

3.7 Reaction times

Reaction time is defined here as the length of the time interval between the appearance of the payoff table and the moment in which the decision is entered. Analysis of reaction times, and a comparison between the high and low discount sessions, may give further insights into the way choices are made in the two cases, and how the intelligence of the group relates to those choices.

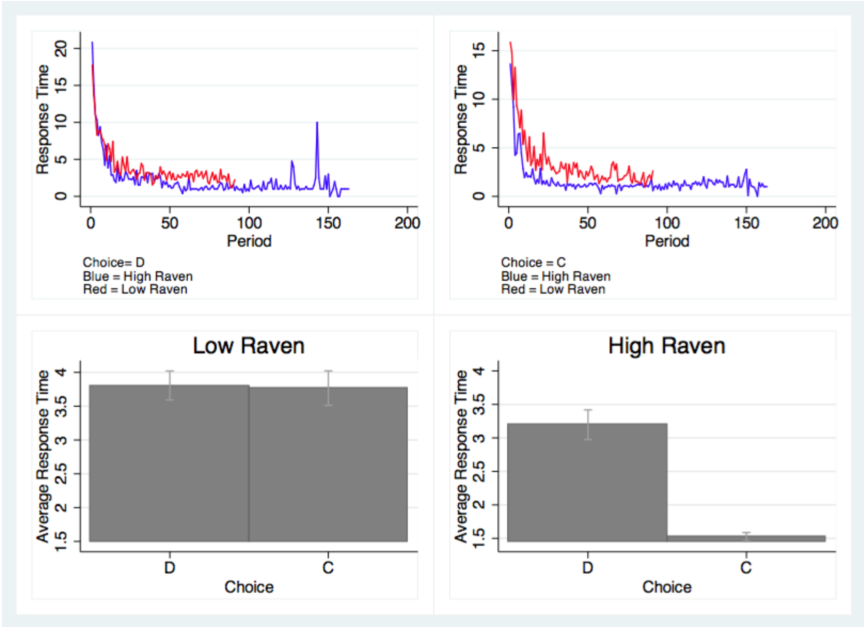
In panel A of figure 3.10, we analyze how the reaction time changes during the periods in the different Raven sessions, and according to the choice to cooperate or defect. There is clear evidence of general learning of the task: the response time decreases with the periods played. This decrease, however, is slower in the low Raven sessions (top graph in panel A of figure 3.10), especially when these subjects choose to cooperate. The histogram in the second row of panel A of figure 3.10 shows that in the low Raven group there is no significant difference in the response time whether the subjects decide to cooperate or defect, but there is a significant difference of about two seconds more when the subjects in the high Raven sessions choose to defect. This seems to suggest that in the high Raven sessions cooperation became the norm, implemented perhaps by default.

Panel B of figure 3.10 shows the reaction times for the session with lower continuation probability. In panel B of figure 3.10, we see a smaller difference in the way reaction time decreases over time in the two different Raven sessions (top row). Moreover, we do not observe the same difference between the choices to cooperate and defect in the high Raven sessions that we observe for the main treatment in panel A of figure 3.10. This further supports the idea that a norm of cooperating was created in the high Raven session in the main treatment, but not for the low continuation probability treatment.

We summarise:

Result 3.7.1. *In the high Raven sessions of the main treatment, the reaction times*

Panel A: Main treatment.



Panel B: Low continuation probability treatment

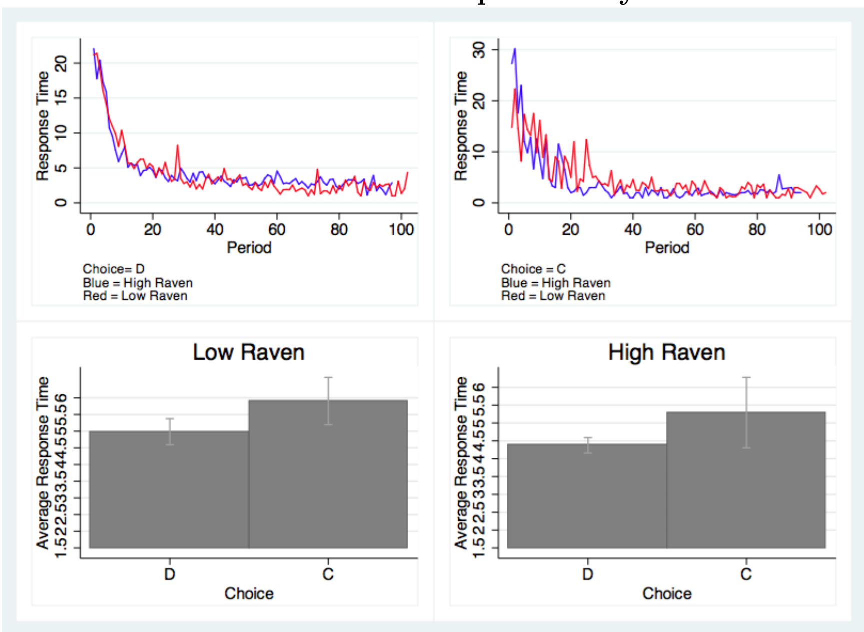


Figure 3.10: **Reaction Time by choice, period and Raven sessions.**
C denotes the Cooperation choice, *D* Defection. The bands represent 95% confidence intervals.

are on average smaller and decline faster over time than in the low Raven sessions of the same treatment. In the high Raven sessions, the reaction times are longer when the subjects choose defection, but are statistically equal in the low Raven sessions. There is no difference between defection and cooperation choices in the high Raven sessions in the low continuation probability treatment.

3.8 Conclusions

Our experimental setup was based on a direct test of the hypothesis that groups of individuals with different levels of intelligence, but who are otherwise similar, would exhibit different levels of cooperation in bilateral interactions with others in the group. The interaction was repeated, so there was time and opportunity for each one to observe and reflect on the past behaviour of the other, and use this inference to guide future choices. A significant and sizeable difference in behaviour and insights into the way in which intelligence is relevant in strategic repeated behaviour emerged.

Everything else being equal, higher intelligence groups exhibit higher levels of cooperation. In our data, the intelligence of the group is associated with different long-run behaviour in a sequence of repeated games played within the group, and higher cooperation rates are associated with higher intelligence.

Higher cooperation rates are produced by interaction over time. Cooperation rates in the initial rounds (approximately 20) are statistically equal in the two groups. Thus, the higher cooperation rate in higher intelligence groups is produced by the experience of past interaction, not by a difference in attitude in the initial stages. There is no inherent association of higher and lower intelligence with a behaviour: the specific history of past interactions is what matters.

Higher cooperation is sensitive to the stage game payoff, so it is not an unconditional inclination of individuals with higher intelligence to cooperate. When the parameters in the experimental design were chosen to make cooperation less long-run profitable, the subjects in groups with higher intelligence also experience large and growing rates of defection over time. Environment and incentives matter: intelligence modulates the response to incentives, and does not directly determine behaviour.

Intelligence matters substantially more than other factors and personality traits. When we test for a statistical relation with the choice to cooperate, we find no significant correlation with personality traits or with high school grades: intelligence as fluid skill is the determining factor. Our design has an asymmetry in the way in which the personality traits and skills are treated, because only intelligence is used to allocate individuals into groups, and the other characteristics are used as controls. Future research should test directly the size and significance of the effect of two or more characteristics (such as, say, intelligence and agreeableness). Of course, intelligence is also in part an outcome of education, and this may involve learning about behaviour in social situations. However, the two Raven groups are similar in their degree of education, which is thus unlikely to be a confounding factor in our results.

Intelligence operates through thinking about strategic choice. Differences in behaviour could arise for different reasons. For instance, intelligence might be associated with the attitude to cooperation, considered as a behavioural inclination, or with a different utility that individuals derive from the outcomes of others. Our data provide support for the idea that intelligence is instead likely to influence the way in which subjects think about the behaviour of others, how they learn about it, and how they choose to modify it as far as possible. Intelligence is relevant for learning and teaching.

We have produced two pieces of evidence supporting this interpretation. The first is the difference in the evolution over time of the response of individuals to the choice of the current partner in the past. A small, but significant difference to the choice to cooperate with the current partner in the last period builds up over the session to produce a substantial cumulative difference in the cooperation rate. The second piece of evidence comes from response times. In higher intelligence subjects, cooperation after the initial stages becomes the default mode. Defection instead requires a specifically dedicated careful balancing of the anticipated loss of future cooperation with the necessity to retaliate to avoid future opportunistic defections of the partner. For lower intelligence groups this difference is absent.

Our data present new evidence and suggest questions for the theory of learning in games. The setup of Dal Bó and Fréchette (2011) that we have adopted puts our subjects in a novel learning environment when there is a substantial lack of homogeneity among subjects. As they proceed in the experimental session, they have the opportunity to observe the behaviour of their peers in the game, and learn about the distribution of characteristics affecting choices in the sample. An adequate model of their sequential choice of actions should incorporate the history of past instances of repeated games in the definition of the strategy. The strategy should also depend on individual characteristics, intelligence being first among them. An initial prior over the distribution of characteristics in the population of the session would then be updated, and thus the distribution over the strategies the subject is facing would change.

The truly novel and interesting side of the research that opens now is the analysis of the link between strategies and intelligence. Is there a systematic pattern of association and what produces it? A natural conjecture may be formulated ranking strategies by their complexity. For example, a very crude way to classify strategies could focus on the length of the history of moves that a strategy considers. Accordingly, a larger set of strategies is available to individuals who are able to implement the more complex ones, as well as to observe, store and process the richer information that is necessary for their execution.[18] A difficulty with this ex-

[18]Rubinstein (1986) and Abreu and Rubinstein (1988) among others suggest a natural way to explicitly introduce intelligence in theoretical models of strategic behaviour, through the use of

planation is that the strategies used by the two groups in our experiment are not substantially different in complexity. Further experimental research to test these initial assumptions seems to us the best way to proceed.

automata models with heterogeneous costs among players for the number of states in the automaton. Players with higher intelligence have lower costs, which will allow them to be more flexible in the sense of being able to increase the number of states in the automation. Thus they can more optimally react to different circumstances. This extension might provide a valuable insight into the way intelligence affects social behaviour.

Appendices

A Trust Experiment: Details

Table A.1: Timeline of Sessions

Order	Trust Game First	Questionnaire First
1	Trust Game	Questionnaire
2	Raven	HL
3	HL	Raven
4	Questionnaire	Trust Game

Table A.2: Dates of Sessions

Day	Session	Subjects	Order	Quest. Incentive
1 (05/05/2015)	1	16	Trust Game First	No
1 (05/05/2015)	2	18	Trust Game First	No
2 (12/05/2015)	3	18	Questionnaire First	No
2 (12/05/2015)	4	14	Questionnaire First	No
3 (13/10/2015)	5	16	Questionnaire First	Yes
3 (13/10/2015)	6	16	Questionnaire First	Yes
3 (13/10/2015)	7	16	Trust Game First	Yes
4 (15/10/2015)	8	18	Trust Game First	Yes
4 (15/10/2015)	9	16	Trust Game First	Yes
4 (15/10/2015)	10	16	Questionnaire First	Yes
5 (05/11/2015)	11	18	Questionnaire First	Yes
		Total: 182		

Experimental script

People show up- tick names and give them cards

Start the experiment

Thank you everyone for coming to our experiment today.

The experiment has 4 parts. Each task will be explained to you either on your screen or by me just before completing.

When you were entering the room you all received a number card. This number corresponds to your participant ID number for this experiment. Please make sure that you are sitting at the correct PC corresponding to the number on the card you received. The whole experiment is completely anonymous so we need the card number to be able to identify you.

I will now load the instructions for the first task on your screens. Please read very carefully as it is critical that you fully understand the task you will be asked to complete. Your payoff will depend on your decisions, so it is very important that you understand the task! If you have any questions, please raise your hand and we will come to help you. Please remain silent while we are running the session, as otherwise we will be forced to terminate!

START TRUST INSTRUNCTIONS

Any questions about the task? Again let me remind you that the length of each match is randomly determined. After completing 5 rounds, there will be an 80% probability that the match will continue for at least another round. You will play with the same person for the entire match. Also, once a match is finished you will be randomly matched with another person for a new match. Additionally, let me remind you that those playing as Player 1, will never find out what decision Player 2 made. Once Player 1 will make a decision, then Player 2 will be allowed to make a choice, while knowing what Player 1 chose. Player 1 will then be informed on how much they received for that round, but will not know what Player 2 chose.

START TRUST

The next section is to solve some puzzles, a pattern game. On the screen, you will see a set of abstract pictures with one of the pictures missing. You need to choose a picture from the choices below to complete the pattern. You will have 30 seconds to complete each set of pictures. The first picture you will see will be an example. You will be asked to solve a total of 30 such puzzles. You will be paid for a random choice of three of these 30 puzzles. For each correct choice you will receive £1. Please make sure to press submit, as otherwise your answer will not be recorded and you might lose money.

START RAVEN

The third section now is a choice task. On your screen you will see a list of 10 lottery choices and for each case you will be asked to indicate which of the lotteries you prefer. One out of these 10 lottery choices will be randomly picked and then the choice you've made will be played and you will be paid according to the probabilities indicated.

START HL

The fourth and last section for today is a questionnaire. It is relevant to your background and personality. Your payment is not affected by these. Again I would like to remind you that everything is anonymous so please answer as truthfully as possible as this is critically important for our research.

Tomorrow morning we will be sending you an excel spreadsheet where the resulting scores for each of the different psychometric measures you will be responding to, will be listed next to your experiment id number. This way you will be able to gain some interesting insights on different factors of your personality and attitudes. Your anonymity will be preserved throughout and it is exactly for this reason why the results will be listed according to your experimental IDs. It is therefore critical that you keep your experimental ID cards safe.

If you have any questions, please raise your hand and we will come to help you.

START QUESTIONAIRE

After finishing the experiment

Thank you for participation today. Please form a queue to receive payment, while respecting the other's privacy while receiving payment.

Participant ID	o	c	e	a	n	Risk Aversion
1.01	3.5	3.708333	4	4.291667	2.458333	0.3
1.02	4.25	2.666667	2.916667	4.208333	3.708333	0.6
1.03	3.375	3.75	3.041667	3.75	3.125	0.4
1.04	4.791667	3.75	3.416667	3.75	2.75	0.3
1.05	2.708333	3.791667	3.25	3.458333	3	0.4
1.06	3.125	3.791667	3.166667	3.083333	3.208333	0.7
1.07	3.5	2.958333	3.25	3.125	3.5	0.6
1.08	3.541667	4.458333	3.541667	4.416667	2	0.4
1.09	3.166667	3.125	3.166667	3.75	3.125	0.5
1.10	2.583333	3.083333	3.041667	3.541667	3.541667	0.6
1.11	3.5	3.416667	3.125	3.583333	2.875	0.8
1.12	3.083333	4.666667	3.083333	3.875	2.708333	0.3
1.13	2.875	3.625	3.166667	3.458333	2.458333	0.7
1.14	2.875	3.583333	4.333333	2.625	2.583333	0.7
1.15	3.083333	4	3.125	3.75	2.583333	0.4
1.16	4.083333	4	4.041667	4	2.25	0.6
2.01	3.125	3.916667	3.5	3.541667	2.166667	0.6
2.02	3.25	3.75	3.541667	3.541667	3.25	0.4
2.03	2.625	4.583333	3.5	2.958333	2.833333	0.4
2.04	4.375	3.875	2.75	4.291667	2.166667	0.3
2.05	3.416667	4.291667	3.083333	3.708333	2.75	0.9
2.06	3.541667	2.916667	2.75	4.375	4.208333	0.4
2.07	3.166667	3.166667	3.125	3	3.041667	0.6
2.08	4.041667	4.125	3.333333	3.5	2.75	0.4
2.09	3.541667	3.333333	3.25	3.5	2.041667	0.7
2.10	4.208333	3.541667	3.333333	3.958333	2.541667	0.3
2.11	2.958333	3.958333	2.291667	3	2.5	0.5
2.12	3.25	4.041667	3.5	3.833333	2.708333	0.3
2.13	3.333333	3.833333	3.5	3.666667	2.5	0.7
2.14	4.083333	4.083333	3.583333	4.666667	2.958333	0.6
2.15	3.458333	4.041667	3.416667	3.041667	2.125	0.4
2.16	3.75	4.25	3.791667	4.208333	2.291667	0.5
3.01	3.75	3.583333	3.083333	4.25	2.625	0.5
3.02	4.458333	3.875	3.916667	4.083333	2.791667	0.6
3.03	3.125	4	3.416667	2.875	2.708333	0.5
3.04	2.875	3.375	3.25	3.541667	2.791667	0.8
3.05	3	3.541667	2.875	3.833333	2.458333	0.7
3.06	3.291667	4.208333	3.458333	3.75	2.625	0.4
3.07	3.5	4	1.791667	3.291667	3.5	0.6
3.08	4.375	4.083333	3.833333	4.458333	2.416667	1
3.09	3.25	2.666667	2.416667	3.333333	4.083333	0.4
3.10	4.083333	3.833333	3.833333	4.583333	2.875	0.7
3.11	3.333333	4.25	3.666667	3.875	2.916667	0.3
3.12	3.5	3.375	3.5	3.916667	1.833333	0.6
3.13	4.5	2.333333	3.166667	3.458333	3.541667	0.5
3.14	4.208333	4.666667	3.583333	3.958333	2	0.9
3.15	3.875	4.083333	3.25	4.375	2.875	0.9
3.16	3.291667	3.833333	3.666667	3.875	3	0.7

Figure A.1: Sample Psychometric Scores Circulated

Email with explanation about psychometric scores

Hi everyone,

Thanks again for taking part in our study yesterday.

You can find your resulting scores on my website: http://www2.warwick.ac.uk/fac/soc/economics/staff/asofianos/experiments

(use the password: 1911 to access the spreadsheet)

Remember that you can find your own scores by finding your experimental IDs in the first column.

The first five variables are the Big Five personality traits. The scores are between 0 and 5, where 5 means a high level of the particular trait. For a brief explanation about each trait check: https://en.wikipedia.org/wiki/Big_Five_personality_traits

Then, 'Risk Aversion' is a measure of how risk averse your preferences are. The bigger the score is (it's between 0 and 1) then the more risk averse you are.

Please handle these results with care, they can give you a broad indication of your psychometric characteristics, but it is well known that they are prone to errors, even large ones!

Thanks,
Andis

Big Five Questionnaire

At the top of each page of the questionnaire the following statement was found:

The following pages contain phrases describing people's behaviours. Please use the rating scale next to each phrase to describe how accurately each statement describes you. Describe yourself as you generally are now, not as you wish to be in the future. Describe yourself as you honestly see yourself, in relation to other people you know of the same sex as you are, and roughly your same age. So that you can describe yourself in an honest manner, your responses will be kept in absolute confidence. Please read each statement carefully, and then click the circle that corresponds to the accuracy of the statement.

All the below statements were rated by the participants according to how accurately they felt each describes themselves. The 5 possible choices were:

1. Very Inaccurate
2. Moderately Inaccurate
3. Neither Accurate Nor Inaccurate
4. Moderately Accurate
5. Very Accurate

Each item is coded from 1 to 5. To obtain the score for each facet, each item is added (or subtracted for negatively coded items). Each factor is obtained by summing up all the facets of the respective factor.

List of items grouped by factors and facets:

Neuroticism:

N1: ANXIETY

+ keyed	Worry about things.
	Fear for the worst.
	Am afraid of many things.
	Get stressed out easily.

N2: ANGER

+ keyed	Get angry easily.
	Get irritated easily.
	Lose my temper.
– keyed	Am not easily annoyed.

N3: DEPRESSION

+ keyed	Often feel blue.
	Dislike myself.
	Am often down in the dumps.
– keyed	Feel comfortable with myself.

N4: SELF-CONSCIOUSNESS

+ keyed	Find it difficult to approach others.
	Am afraid to draw attention to myself.
	Only feel comfortable with friends.
– keyed	Am not bothered by difficult social situations.

N5: IMMODERATION

+ keyed	Go on binges.
– keyed	Rarely overindulge.
	Easily resist temptations.
	Am able to control my cravings.

N6: VULNERABILITY

+ keyed	Panic easily.
	Become overwhelmed by events.
	Feel that I'm unable to deal with things.
– keyed	Remain calm under pressure.

Extraversion:

E1: FRIENDLINESS

+ keyed	Make friends easily.
	Feel comfortable around people.
– keyed	Avoid contacts with others.
	Keep others at a distance.

E2: GREGARIOUSNESS

+ keyed	Love large parties.
	Talk to a lot of different people at parties.
– keyed	Prefer to be alone.
	Avoid crowds.

E3: ASSERTIVENESS

+ keyed	Take charge.
	Try to lead others.
	Take control of things.
– keyed	Wait for others to lead the way.

E4: ACTIVITY LEVEL

+ keyed	Am always busy.
	Am always on the go.
	Do a lot in my spare time.
– keyed	Like to take it easy.

E5: EXCITEMENT-SEEKING

+ keyed	Love excitement.
	Seek adventure.
	Enjoy being reckless.
	Act wild and crazy.

E6: CHEERFULNESS

+ keyed	Radiate joy.
	Have a lot of fun.
	Love life.
	Look at the bright side of life.

Openness:

O1: IMAGINATION

+ keyed	Have a vivid imagination.
	Enjoy wild flights of fantasy.
	Love to daydream.
	Like to get lost in thought.

O2: ARTISTIC INTERESTS

+ keyed	Believe in the importance of art.
	See beauty in things that others might not notice.
– keyed	Do not like poetry.
	Do not enjoy going to art museums.

O3: EMOTIONALITY

+ keyed	Experience my emotions intensely.
	Feel others' emotions.
– keyed	Rarely notice my emotional reactions.
	Don't understand people who get emotional.

O4: ADVENTUROUSNESS

+ keyed	Prefer variety to routine.
– keyed	Prefer to stick with things that I know.
	Dislike changes.
	Am attached to conventional ways.

O5: INTELLECT

+ keyed	Love to read challenging material.
– keyed	Avoid philosophical discussions.
	Have difficulty understanding abstract ideas.
	Am not interested in theoretical discussions.

O6: LIBERALISM

+ keyed	Tend to vote for liberal political candidates.
	Believe that there is no absolute right and wrong.
– keyed	Tend to vote for conservative political candidates.
	Believe that we should be tough on crime.

Agreeableness:

A1: TRUST

+ keyed	Trust others.
	Believe that others have good intentions.
	Trust what people say.
– keyed	Distrust people.

A2: MORALITY

– keyed	Use others for my own ends.
	Cheat to get ahead.
	Take advantage of others.
	Obstruct others' plans.

A3: ALTRUISM

+ keyed	Am concerned about others.
	Love to help others.
– keyed	Am indifferent to the feelings of others.
	Take no time for others.

A4: COOPERATION

– keyed	Love a good fight.
	Yell at people.
	Insult people.
	Get back at others.

A5: MODESTY

– keyed	Believe that I am better than others.
	Think highly of myself.
	Have a high opinion of myself.
	Boast about my virtues.

A6: SYMPATHY

+ keyed	Sympathize with the homeless.
	Feel sympathy for those who are worse off than myself.
– keyed	Am not interested in other people's problems.
	Try not to think about the needy.

Conscientiousness:

C1: SELF-EFFICACY

+ keyed	Complete tasks successfully.
	Excel in what I do.
	Handle tasks smoothly.
	Know how to get things done.

C2: ORDERLINESS

+ keyed	Like to tidy up.
– keyed	Often forget to put things back in their proper place.
	Leave a mess in my room.
	Leave my belongings around.

C3: DUTIFULNESS

+ keyed	Keep my promises.
	Tell the truth.
– keyed	Break rules.
	Break my promises.

C4: ACHIEVEMENT-STRIVING

+ keyed	Do more than what's expected of me.
	Work hard.
– keyed	Put little time and effort into my work.
	Do just enough work to get by.

C5: SELF-DISCIPLINE

+ keyed	Am always prepared.
	Carry out my plans.
– keyed	Waste my time.
	Have difficulty starting tasks.

C6: CAUTIOUSNESS

– keyed	Jump into things without thinking.
	Make rash decisions.
	Rush into things.
	Act without thinking.

B Trust Experiment: Screen Snapshots

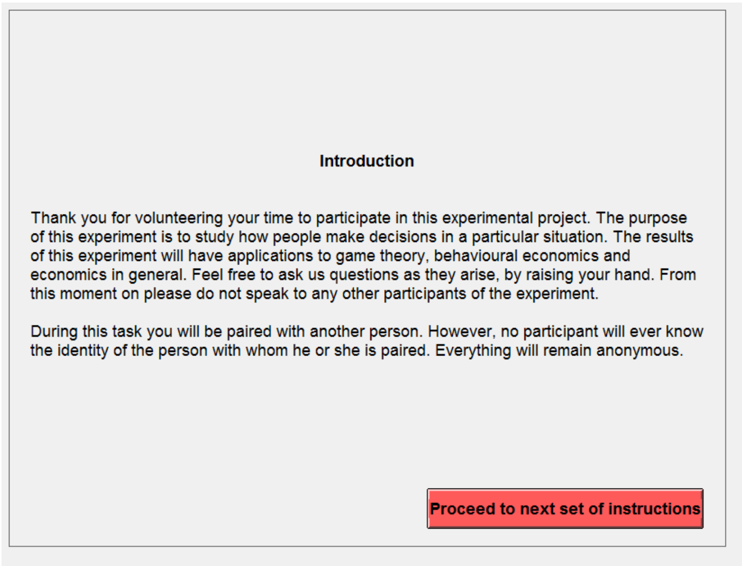


Figure B.1: Introductory Instructions Screen

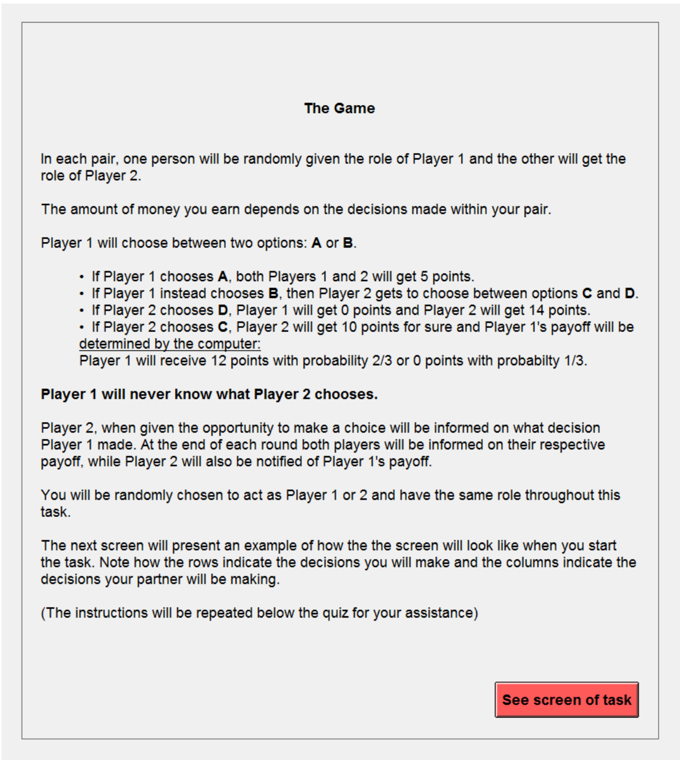


Figure B.2: Stage Game Instructions

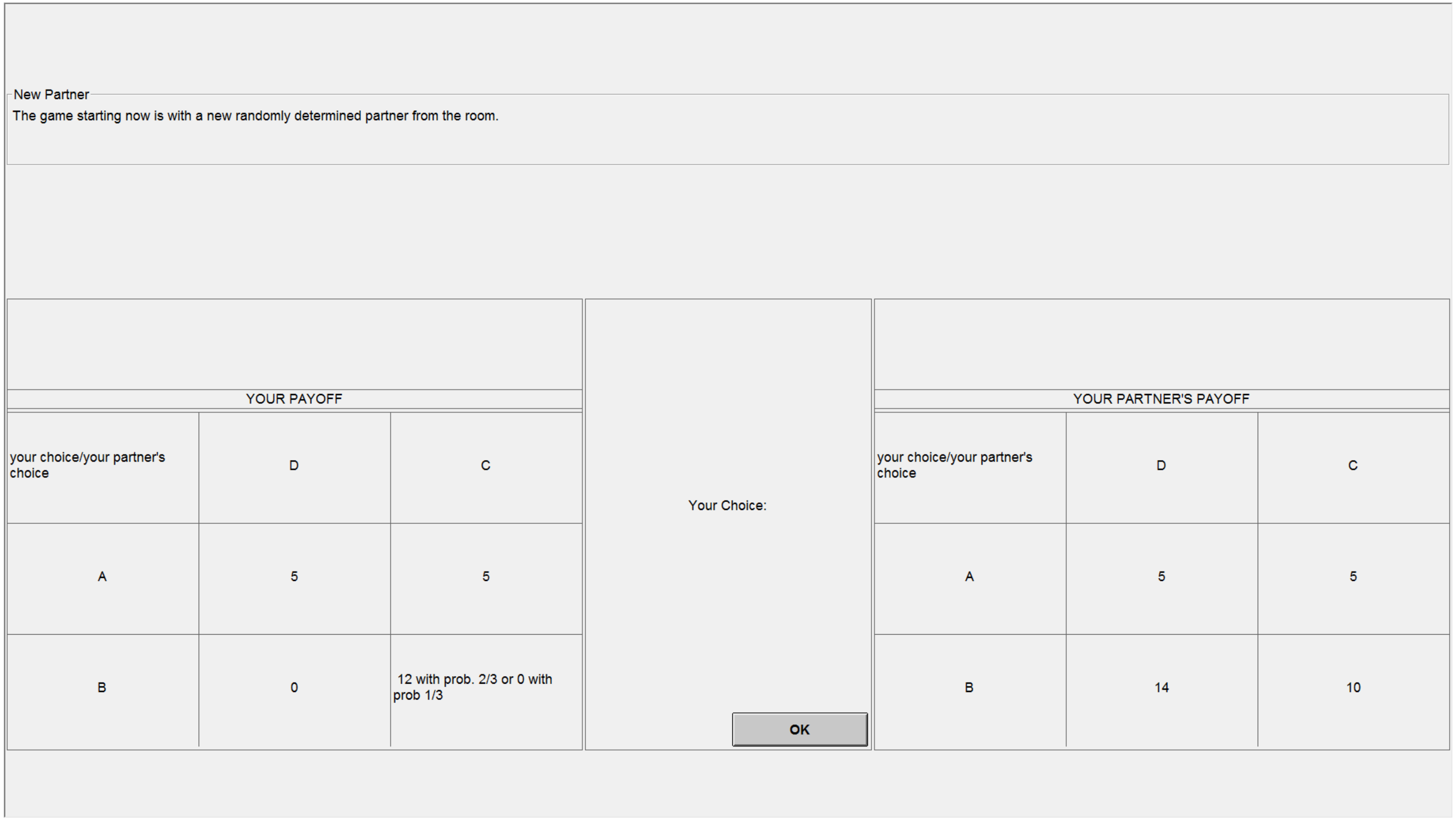
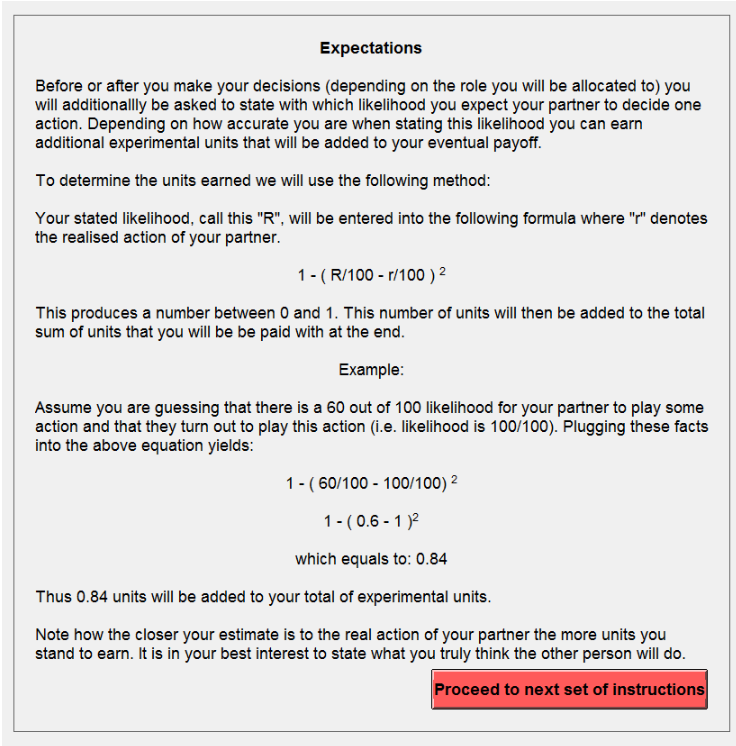


Figure B.3: Example Screen of Game



Expectations

Before or after you make your decisions (depending on the role you will be allocated to) you will additionallly be asked to state with which likelihood you expect your partner to decide one action. Depending on how accurate you are when stating this likelihood you can earn additional experimental units that will be added to your eventual payoff.

To determine the units earned we will use the following method:

Your stated likelihood, call this "R", will be entered into the following formula where "r" denotes the realised action of your partner.

$$1 - (R/100 - r/100)^2$$

This produces a number between 0 and 1. This number of units will then be added to the total sum of units that you will be be paid with at the end.

Example:

Assume you are guessing that there is a 60 out of 100 likelihood for your partner to play some action and that they turn out to play this action (i.e. likelihood is 100/100). Plugging these facts into the above equation yields:

$$1 - (60/100 - 100/100)^2$$

$$1 - (0.6 - 1)^2$$

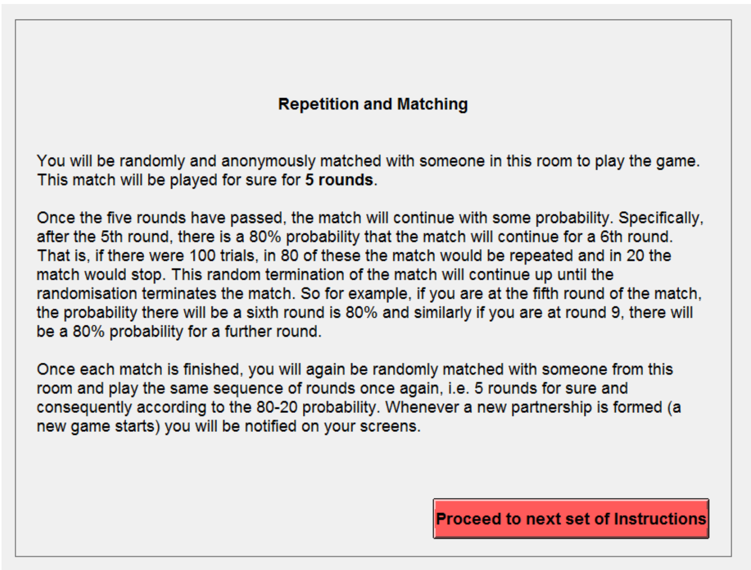
which equals to: 0.84

Thus 0.84 units will be added to your total of experimental units.

Note how the closer your estimate is to the real action of your partner the more units you stand to earn. It is in your best interest to state what you truly think the other person will do.

Proceed to next set of instructions

Figure B.4: Subjective Beliefs Instructions



Repetition and Matching

You will be randomly and anonymously matched with someone in this room to play the game. This match will be played for sure for **5 rounds**.

Once the five rounds have passed, the match will continue with some probability. Specifically, after the 5th round, there is a 80% probability that the match will continue for a 6th round. That is, if there were 100 trials, in 80 of these the match would be repeated and in 20 the match would stop. This random termination of the match will continue up until the randomisation terminates the match. So for example, if you are at the fifth round of the match, the probability there will be a sixth round is 80% and similarly if you are at round 9, there will be a 80% probability for a further round.

Once each match is finished, you will again be randomly matched with someone from this room and play the same sequence of rounds once again, i.e. 5 rounds for sure and consequently according to the 80-20 probability. Whenever a new partnership is formed (a new game starts) you will be notified on your screens.

Proceed to next set of Instructions

Figure B.5: Repetition & Matching Instructions

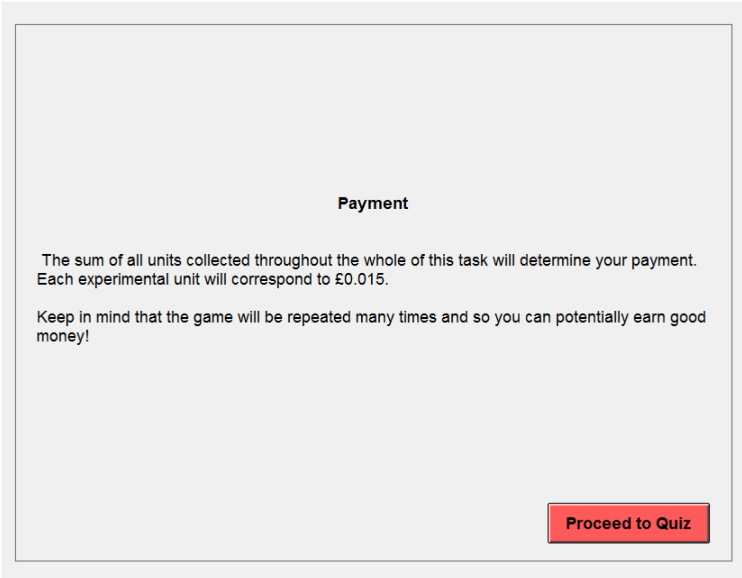


Figure B.6: Payment Instructions

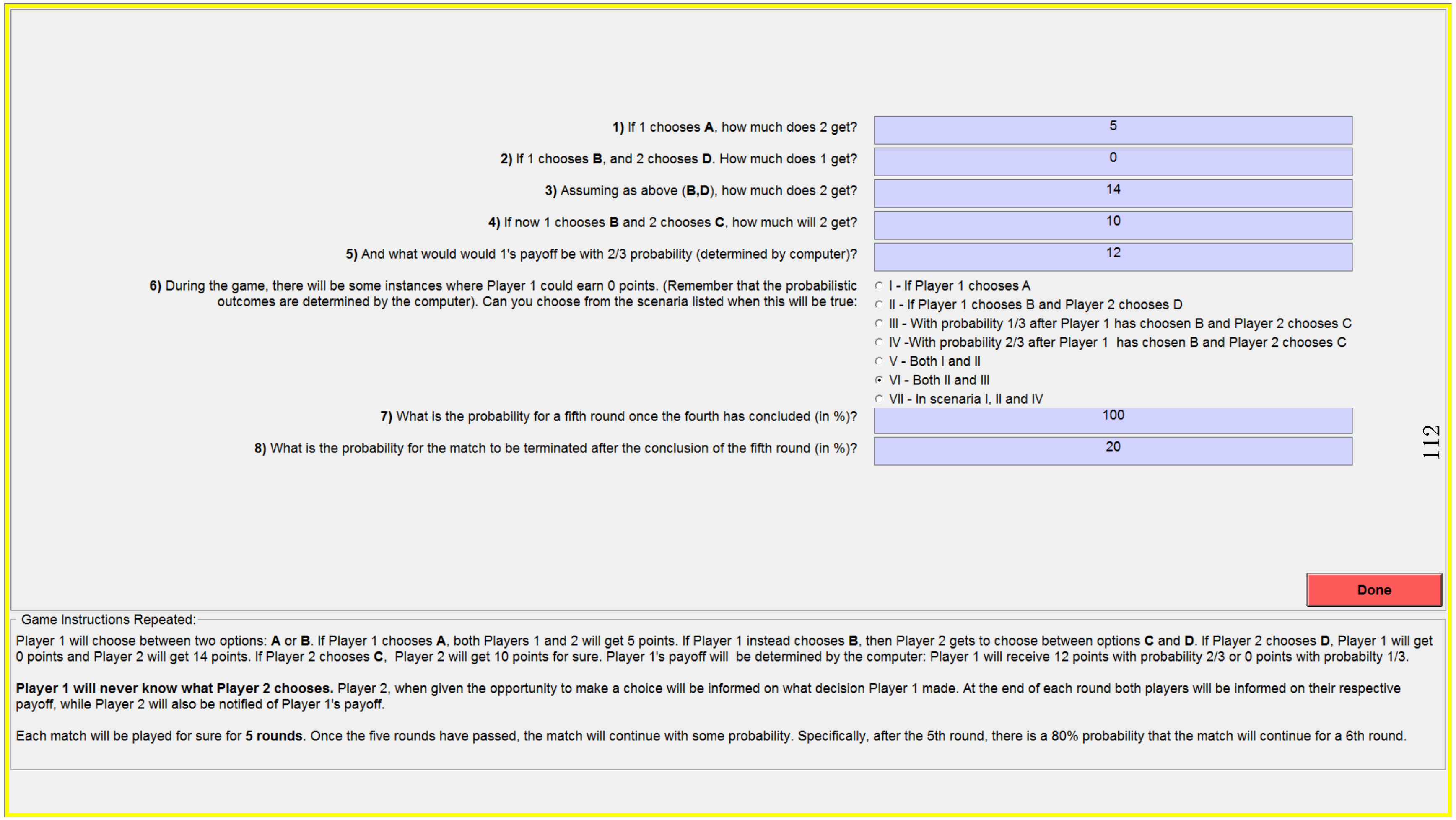


Figure B.7: Quiz - with correct answers filled in

Figure B.8: Trustor Snapshot

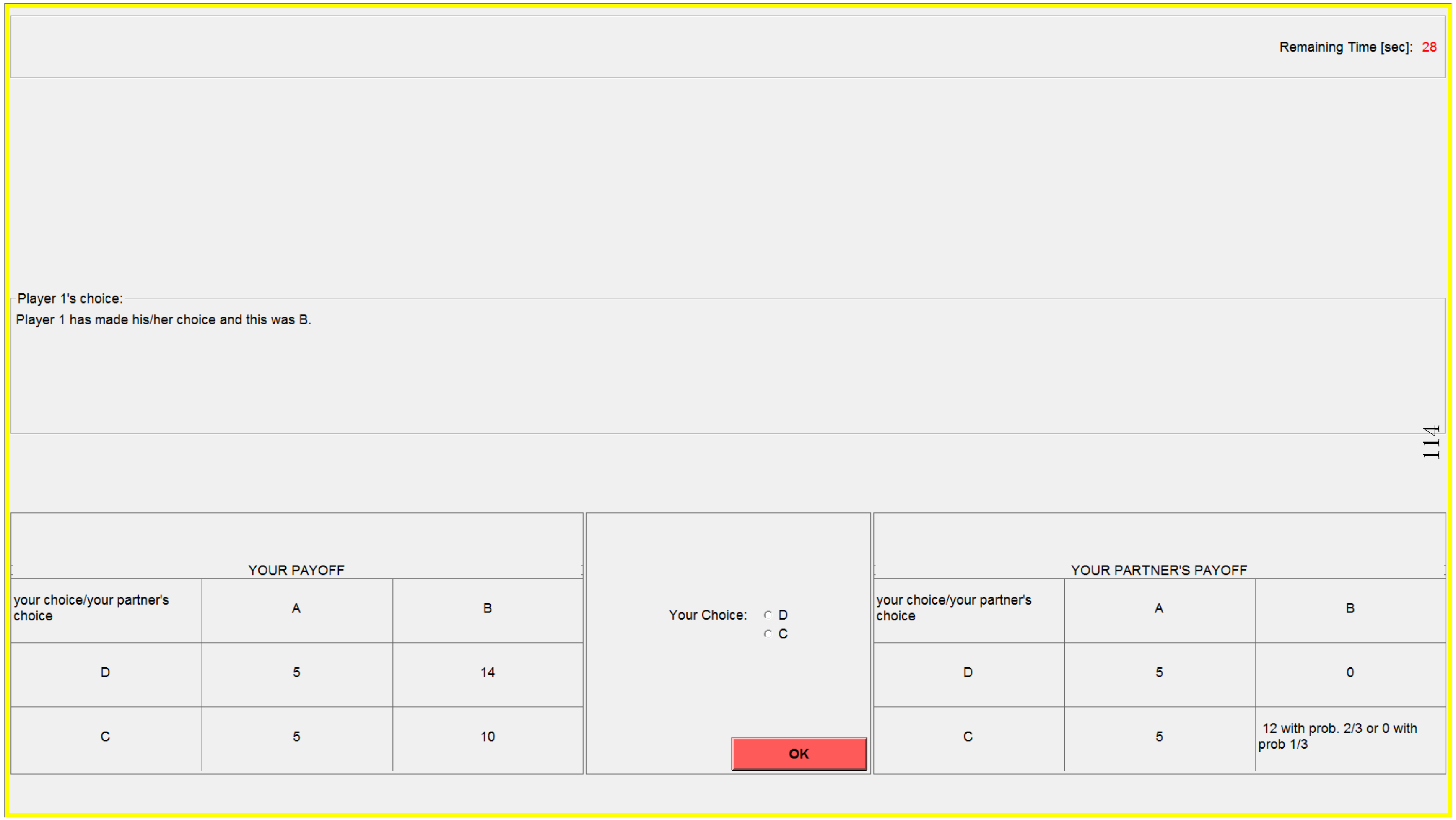


Figure B.9: Trustee Snapshot

C Cooperation Experiment: Timeline of the Experiment

Day One

1. Participants were assigned a number indicating session number and specific ID number. The specific ID number corresponded to a computer terminal in the lab. For example, the participant on computer number 13 in session 4 received the number: 4.13.

2. Participants sat at their corresponding computer terminals, which were in individual cubicles.

3. Instructions about the Raven task were read together with an explanation on how the task would be paid.

4. The Raven test was administered (30 matrices for 30 seconds each matrix). Three randomly chosen matrices out of 30 tables were paid at the rate of 1 GBP per correct answer.

5. The Holt-Laury task was explained on a white board with an example, as well as the payment for the task.

6. The Holt-Laury choice task was completed by the participants (10 lottery choices). One randomly chosen lottery out of 10 played out and paid (Subjects in sessions 1 & 2 did NOT have this).

7. The questionnaire was presented and filled out by the participants.

Between Day One & Two

1. Allocation to *high* and *low* groups made. An email was sent out to all participants listing their allocation according to the number they received before starting Day One.

Day Two

1. Participants arrived and were given a new ID corresponding to the ID they received in Day One. The new ID indicated their new computer terminal number at which they were sat.

2. The prisoner's dilemma game was explained on a white-board, as was the way the matching between partners, the continuation probability and how the payment would be made.

3. The infinitely repeated prisoner's dilemma game was played. Each experimental unit earned corresponded to 0.004 GBP.

4. The questionnaire was presented and filled out by the participants.

5. Calculation of payment was made and subjects were paid accordingly.

D Cooperation Experiment: Dates and Details

Tables D.1 and D.2 below illustrate the dates and timings of each session. In the top panels the total number of subjects that participated in Day 1 of the experiment is listed and by comparing with the corresponding 'Total Returned' column from the bottom panels it becomes apparent that there is relatively small attrition between Day 1 and Day 2. For example, for the main treatment, only 10 subjects out of 140 did not return on Day 2.

Table D.1: Dates and details for main treatment

Day 1: Group Allocation

	Date	Time	Subjects
1	18/06/2013	10:00	15
2	18/06/2013	11:00	19
Total			34
3	5/11/2013	11:00	18
4	5/11/2013	12:00	18
Total			36
5	26/11/2013	10:00	18
6	26/11/2013	11:00	17
7	26/11/2013	12:00	18
8	26/11/2013	13:00	17
Total			70

Day 2: Cooperation Task

	Date	Time	Subjects	Group
Session 1	20/06/2013	10:00	14	High Raven
Session 2	20/06/2013	11:30	16	Low Raven
Total Returned			30	
Session 3	7/11/2013	11:00	18	High Raven
Session 4	7/11/2013	12:30	16	Low Raven
Total Returned			34	
Session 5	27/11/2013	13:00	18	High Raven
Session 6	27/11/2013	14:30	12	Low Raven
Session 7	28/11/2013	13:00	16	High Raven
Session 8	28/11/2013	14:30	20	Low Raven
Total Returned			66	

Table D.2: Dates and details for low continuation probability treatment

Day 1: Group Allocation

	Date	Time	Subjects
1	11/06/2013	10:00	17
2	11/06/2013	11:00	17
3	11/06/2013	12:00	19
4	11/06/2013	13:00	14
Total			67

Day 2: Cooperation Task

	Date	Time	Subjects	Group
Session 1ld	13/06/2013	10:00	14	High Raven
Session 2ld	13/06/2013	11:30	16	Low Raven
Session 3ld	13/06/2013	13:00	16	High Raven
Session 4ld	13/06/2013	14:30	14	Low Raven
Total Returned			60	

E Cooperation Experiment: Additional Details

Table E.1: Low Raven Sessions, Main Variables

Variable	Mean	Std. Dev.	Min.	Max.	N
Choice	0.426	0.494	0	1	5332
Partner Choice	0.428	0.495	0	1	5332
Age	22.345	4.693	18	51	5332
Female	0.624	0.484	0	1	5332
Period	42.264	24.242	1	91	5332
Openness	3.639	0.527	2.5	5	5332
Conscientiousness	3.404	0.645	2	5	5332
Extraversion	3.35	0.729	1	4.75	5332
Agreableness	3.84	0.583	2	4.778	5332
Neuroticism	2.899	0.8	1	5	5332
Raven	14.367	2.709	6	18	5332
Economist	0.06	0.238	0	1	5332
Risk Aversion	5.559	1.149	3	8	4052
Final Profit	2774.297	397.304	1731	3628	64
Profit x Period	33.269	4.216	21.638	45.075	64
Total Periods	83.313	4.272	80	91	64

Table E.2: High Raven Sessions, Main Variables

Variable	Mean	Std. Dev.	Min.	Max.	N
Choice	0.694	0.461	0	1	7688
Partner Choice	0.694	0.461	0	1	7688

Continued on next page...

... table E.2 continued

Variable	Mean	Std. Dev.	Min.	Max.	N
Age	20.865	2.746	18	36	7688
Female	0.461	0.499	0	1	7688
Period	65.538	42.27	1	163	7688
Openness	3.612	0.59	1.9	4.9	7688
Conscientiousness	3.361	0.739	1.444	4.889	7688
Extraversion	3.228	0.738	1.875	4.5	7688
Agreableness	3.768	0.621	2.333	5	7688
Neuroticism	2.799	0.72	1.25	4.5	7688
Raven	20.331	1.947	16	25	7688
Economist	0.121	0.326	0	1	7688
Risk Aversion	5.541	1.721	2	9	6064
Final Profit	4675.303	2034.416	1447	7752	66
Profit x Period	38.547	5.834	25.386	47.558	66
Total Periods	116.485	40.093	57	163	66

Table E.3: High Raven Session 1ld , Main Variables

Variable	Mean	Std. Dev.	Min.	Max.	N
Choice	0.143	0.35	0	1	1407
Partner Choice	0.143	0.35	0	1	1407
Age	22.688	2.418	18	27	1407
Female	0.5	0.5	0	1	1407
Period	44.531	25.393	1	88	1407
Openness	3.481	0.373	2.7	4.2	1407

Continued on next page...

... table E.3 continued

Variable	Mean	Std. Dev.	Min.	Max.	N
Conscientiousness	3.291	0.556	2.111	4.222	1407
Extraversion	3.235	0.716	1.875	4.625	1407
Agreableness	3.541	0.58	2.444	4.444	1407
Neuroticism	2.789	0.625	1.875	4.25	1407
Raven	19.439	1.368	18	22	1407
Economist	0.25	0.433	0	1	1407
Final Profit	2401	151.452	2076	2655	15
Profit x Period	27.284	1.721	23.591	30.17	15
Total Periods	88	0	88	88	15

Table E.4: Low Raven Session 2ld , Main Variables

Variable	Mean	Std. Dev.	Min.	Max.	N
Choice	0.299	0.458	0	1	1428
Partner Choice	0.299	0.458	0	1	1428
Age	23.286	4.08	18	34	1428
Female	0.714	0.452	0	1	1428
Period	51.5	29.454	1	102	1428
Openness	3.736	0.461	3.2	4.600	1428
Conscientiousness	3.857	0.663	2.889	5	1428
Extraversion	3.732	0.526	2.625	4.375	1428
Agreableness	4.024	0.570	2.889	4.778	1428
Neuroticism	2.429	0.919	1.125	4.625	1428
Raven	13.429	3.757	5	17	1428

Continued on next page...

... table E.4 continued

Variable	**Mean**	**Std. Dev.**	**Min.**	**Max.**	**N**
Economist	0.071	0.258	0	1	1428
Final Profit	3040.143	213.331	2670	3450	14
Profit x Period	29.805	2.091	26.176	33.824	14
Total Periods	102	0	102	102	14

Table E.5: High Raven Sessions 3ld, Main Variables

Variable	**Mean**	**Std. Dev.**	**Min.**	**Max.**	**N**
Choice	0.116	0.32	0	1	1552
Partner Choice	0.116	0.32	0	1	1552
Age	22.5	1.937	18	26	1552
Female	0.75	0.433	0	1	1552
Period	49	28.009	1	97	1552
Openness	3.45	0.52	2	4.3	1552
Conscientiousness	3.674	0.504	3	4.667	1552
Extraversion	3.344	0.637	2.125	4.25	1552
Agreableness	3.819	0.602	2.222	4.667	1552
Neuroticism	2.758	0.638	1.75	3.75	1552
Raven	19.375	1.495	17	22	1552
Economist	0.313	0.464	0	1	1552
Final Profit	2601.25	126.24	2380	2810	16
Profit x Period	26.817	1.301	24.536	28.969	16
Total Periods	97	0	97	97	16

Table E.6: Low Raven Sessions 4ld, Main Variables

Variable	Mean	Std. Dev.	Min.	Max.	N
Choice	0.163	0.37	0	1	294
Partner Choice	0.163	0.37	0	1	294
Age	21.071	2.157	18	25	294
Female	0.5	0.501	0	1	294
Period	11	6.066	1	21	294
Openness	3.679	0.72	2.3	4.9	294
Conscientiousness	3.54	0.542	2.222	4.444	294
Extraversion	3.268	0.707	2.25	4.625	294
Agreableness	3.619	0.387	3.111	4.222	294
Neuroticism	2.839	0.859	1.625	4	294
Raven	14.286	2.123	10	17	294
Economist	0.214	0.411	0	1	294
Final Profit	575.571	79.642	480	750	14
Profit x Period	27.408	3.792	22.857	35.714	14
Total Periods	21	0	21	21	14

Table E.7: Correlations Table (p$-$*values* in brackets)

Variables	Raven	Female	Risk Aversion	Openness	Conscientiousness	Extraversion	Agreableness	Neuroticism
Raven	1.000							
Female	-0.160	1.000						
	(0.068)							
Risk Aversion	0.030	-0.039	1.000					
	(0.764)	(0.699)						
Openness	-0.152	-0.017	-0.086	1.000				
	(0.084)	(0.844)	(0.396)					
Conscientiousness	0.085	0.004	0.073	0.157	1.000			
	(0.337)	(0.965)	(0.470)	(0.075)				
Extraversion	-0.076	-0.086	0.004	0.319	0.054	1.000		
	(0.391)	(0.330)	(0.970)	(0.000)	(0.539)			
Agreableness	-0.020	-0.052	-0.106	0.183	0.269	0.183	1.000	
	(0.823)	(0.554)	(0.296)	(0.038)	(0.002)	(0.037)		
Neuroticism	-0.036	0.424	0.072	-0.130	-0.305	-0.315	-0.351	1.000
	(0.684)	(0.000)	(0.478)	(0.141)	(0.000)	(0.000)	(0.000)	

Table E.8: Individual strategies in the different Raven sessions in the last 5 and first 5 repeated games

Raven Session Repeated Games	High Last 5	Low Last 5	High First 5	Low First 5
Strategy				
Always Cooperate	0	0	0	0.0410
	(0.0055)	(0.0079)	(0.0068)	(0.0436)
Always Defect	0.0417	0.4130***	0.3165***	0.3107***
	(0.0318)	(0.1024)	(0.1076)	(0.0884)
Grim after 1 D	0.3269***	0.1069*	0.5374**	0.2226***
	(0.1050)	(0.0646)	(0.1144)	(0.0772)
Tit for Tat (C first)	0.2316**	0.2890***	0	0.2396***
	(0.1059)	(0.0774)	(0.0790)	(0.0673)
Tit For Tat (D First)	0.0000	0.0600	0.0478**	0.0819
	(0.0010)	(0.0457)	(0.0480)	(0.0649)
Win Stay Lose Shift	0.0623	0	0.0377	0.0159
	(0.0660)	(0.0548)	(0.0423)	(0.0549)
Grim after 2 D	0.0000	0	0.0313	0
	(0.0553)	(0.0100)	(0.0533)	(0.0378)
Tit for Tat (after D D C)†	0.1201*	0.0953**	0.0000	0.0739
	(0.0616)	(0.0453)	(0.0139)	(0.0979)
Tit For Tat (after D C C) ††	0.1223	0	0.0000	0
	(0.0864)	(0.0129)	(0.0207)	(0.0332)
Tit For Tat (after D D C C)	0	0	0.0292	0
	(0.0302)	(0.0584)	(0.0528)	(0.0021)
Grim after 3 D	0.0951	0	0.0000	0
	(0.0645)	(0.0042)	(0.0124)	(0.0402)
Tit For Tat (after D D D C)	0	0.0358	0	0
Gamma	0.3179***	0***	0***	0.0410***
	(0,0553)	(0.0079)	(0.0068)	(0.0436)
beta	0.959	0.936	0.881	0.839
Sessions	1,5,7	2,4, 6, 8	1,5,7	2,4,6, 8
Average Rounds	4.83	5.12	2.11583	3.875
N. Subjects	48	64	48	64
Observations	1090	1676	518	1152

Note: Each coefficient represents the probability estimated using the ML of the corresponding strategy. Std error is reported in brackets. Gamma is the error coefficient that is estimated for the choice function used in the ML and beta is the probability estimated that the choice by a subject is equal to what the strategy prescribes.††† Tests equality to 0 using the Waldtest: $^{*}\ p-values < 0.1$, $^{**}\ p-values < 0.05\ ^{**}$, $p-values < 0.01\ ^{***}$

† Tit for Tat (after D D C) stands for the lenient Tit for Tat strategy that punishes only after observing two defections from the partner and returns to cooperation after observing cooperation once.

†† Tit for Tat (after D C C) stands for the Tit for Tat strategy that punishes after 1 defection but only returns to cooperation after observing cooperation twice from the partner.

††† When beta is close to 1/2, the choices are essentialy random and when it is close to 1 then choices are almost perfectly predicted.

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